Food and Agriculture Organization of the United Nations

Forests for human health and well-being

Strengthening the forest–health–nutrition nexus

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Forests for human health and well-being

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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CONTENTS

Foreword iv
Acknowledgements v
Acronyms vi

1. **INTRODUCTION: THE FOREST, HUMAN HEALTH AND NUTRITION NEXUS** 1

2. **FOREST CONTRIBUTIONS TO THE HEALTH OF PEOPLE LIVING IN OR NEAR FORESTS** **7**
Direct consumption of forest foods for good nutrition and health 7
Forest-based incomes supporting human nutrition and health 12
Medicines from the forest 13
Woodfuel: a source of health benefits as well as risks 16
Cultural, spiritual and mental health 17
Recommendations: how to promote good health of forest people 18

3. **ROLE OF FORESTS IN THE HEALTH OF URBAN POPULATIONS AND INDUSTRIALIZED SOCIETIES** **23**
Forest products and healthy diets 24
Forest pharmaceuticals 25
Mental, physiological and social health benefits associated with forests 26
Recommendations: how to take advantage of forests to promote health and nutrition in urban societies 33

4. **HEALTH CONSEQUENCES WHEN FORESTS AND TRADITIONAL FOREST COMMUNITIES BECOME ALTERED** **41**
Health issues associated with a changing way of life for forest dwellers 41
Erosion of traditional knowledge 43
Transmissible diseases 43
Emerging zoonoses 44
Climate change effects on the forest–health nexus 46

5. **POLICIES AND GOOD PRACTICES AT THE FOREST, HEALTH AND NUTRITION NEXUS** **49**
One Health 49
Harmonizing conservation with livelihoods and human health 49
Sustainable wildlife management 51
Valourization of traditional knowledge 52

6. WAYS FORWARD **55**
Key recommendations 58

References **61**

FOREWORD

Forests provide goods and services, employment and income to perhaps 2.5 billion people worldwide. Recognition of the importance of forests for food security and nutrition has significantly increased in recent years. Since the first International Conference on Forests for Food Security and Nutrition in 2013, FAO has made efforts to promote cross-sectoral collaboration to achieve sustainable forestry, agriculture and food security and nutrition simultaneously. Such efforts prompted the endorsement of policy recommendations on sustainable forestry for food security and nutrition at the forty-fourth session of the Committee on World Food Security in October 2017.

This publication goes one step forward by introducing health into the recommendations on the linkages between forests, nutrition and food security. Its aim is to expand cross-sectoral collaboration to a new set of stakeholders who are vital to unlocking the full potential of forests for contributing to greater human well-being. Nutrition and health are intrinsically connected: Good nutrition cannot be achieved without good health and vice versa. Yet forests also provide a wide range of benefits to human health and well-being beyond those generally addressed in connection with the food security and nutrition framework.

The COVID-19 pandemic reminds us that the health and well-being of humans, animals and the environment are closely interlinked – the One Health concept, as described in this publication – and that changes are needed in the way humans engage with nature. Raising awareness that forests are essential for the well-being of all people, and creating an enabling environment in which people can benefit from forests, can help transform people's interactions with these ecosystems, especially in a rapidly urbanizing world.

This publication offers an opportunity to delve into the forest–nutrition–health nexus in diverse contexts (specifically rural versus urban settings) and presents examples of policies, good practices and recommendations for each context. It concludes with a set of global recommendations, addressed to policy-makers, which we hope will be a source of inspiration to further support cross-sectoral approaches in developing policies, programmes and projects, particularly in forestry, food security, nutrition and health.

Mette L. Wilkie
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ACRONYMS

ADHD	attention deficit hyperactivity disorder
FAO	Food and Agriculture Organization of the United Nations
FTB	forest therapy base
FTR	forestry therapy road
KFS	Korea Forest Service
NCD	non-communicable disease
NWFP	non-wood forest product
SDG	Sustainable Development Goal
T&CM	traditional and complementary medicine
WHO	World Health Organization

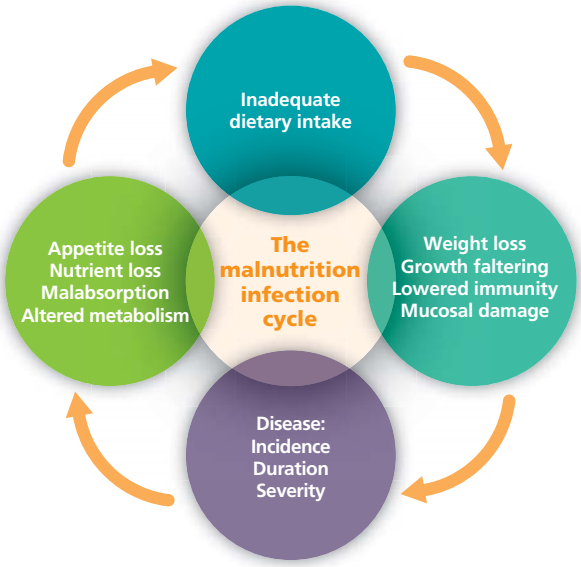
1. INTRODUCTION: THE FOREST, HUMAN HEALTH AND NUTRITION NEXUS

Forests provide, directly or indirectly, important health benefits for all people. Health-enhancing qualities of forests are a result of multiple and mutually reinforcing benefits. For many communities in and near forests, in both developing and developed countries, biodiversity-rich forest ecosystems provide edible products that contribute to a healthy diet, such as fruits, leaves and mushrooms, as well as a vast number of medicinal plants. Forest environmental services include provision of freshwater resources, flood control, soil fertility, microclimate regulation and habitat for biodiversity. However, forests also contribute to human health in less direct ways, and for people less directly associated with forest habitat, including those living in urban areas.

In discussing the overall role of forests for human health, the concept of health has to be understood widely to include not only treatment of diagnosed illnesses, but also ways to sustain health and well-being and prevent illness. The World Health Organization (WHO), in its constitution, defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity", which stresses the importance of preventive as well as curative health measures. Even more broadly, health can be considered not only in terms of the individual, but also in relation to the well-being of the community, which in turn depends on the well-being of the environment.

Nutrition security is an important component of human health. Good nutrition is crucial for health, enabling the body to defend itself and to recover from disease. Furthermore, good health is crucial for nutrition, enabling the body to absorb vital nutrients. Malnutrition increases susceptibility to infection, severity of health impacts and mortality, and infection exacerbates malnutrition, in a vicious cycle of repeated infections, reduced immunity and deteriorating nutritional status (Figure 1). Malnutrition is the primary

FIGURE 1. The vicious cycle of malnutrition and infection



Source: Katona and Katona-Apte, 2008.

cause of immunodeficiency worldwide, with infants, children, adolescents and the elderly most affected (Katona and Katona-Apte, 2008). In combination with infectious diseases such as acute respiratory infection, malaria, measles and diarrhoeal diseases, undernutrition among children can be lethal, as it magnifies the effects of disease. Healthy diets, as an important component of good nutrition, are also critical to reduce the risks of overweight, obesity and related non-communicable diseases (NCDs).

As key health problems, climatic conditions and the accessibility, type and integrity of forests vary in different parts of the world, the role of forests in sustaining and promoting human health varies among continents and regions. This role is also influenced by the place of forests in people's culture and livelihoods. All people benefit indirectly from the multiple environmental services that forests provide, such as carbon sequestration, temperature control and air purification. However, for populations living in close proximity to forests or depending on them for their livelihoods, forest products and the forest environment may have a more direct role in human health. For urban populations the benefits may be less obvious.

Millions of rural women, men and children obtain both macro- and micronutrients from wild forest foods such as nuts, roots, fruits, seeds, mushrooms, insects, leaves, honey and wild meat. Forest employment and income enable people to purchase food to ensure healthy and diversified diets throughout the year. Woodfuel from forests, by offering the means for food processing, cooking and sterilizing water, directly contributes to food utilization and to decreasing the occurrence of food- and waterborne diseases. This is vital, as waterborne diarrhoeal diseases, for example, are responsible for 2 million deaths each year, with the majority occurring in children under five (WHO and UNICEF, 2000). Forests also have a filtering role in provision of freshwater, with approximately 75 percent of the world's accessible freshwater coming from forested watersheds (Millennium Ecosystem Assessment, 2005).

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In the Democratic Republic of the Congo, the leaves of *Gnetum* sp. are consumed as a leaf vegetable and provide revenue for women, further contributing to food security and nutrition

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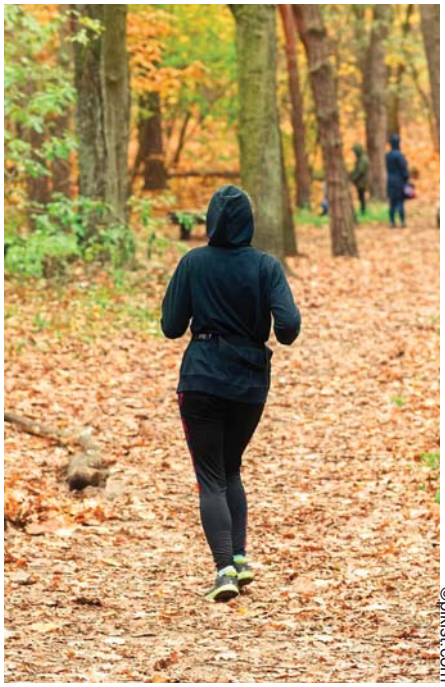
Nutritious honey, fresh from the hive, Nepal

Populations living in or near forests are often distant from centralized health services and may be more dependent on forest-derived medicines in traditional health care systems, including indigenous or folk medicine, for a wide array of ailments (Pierce Colfer *et al.*, 2006). For instance, over 1 billion people worldwide use herbal and home remedies to treat children's diarrhoea (FAO, 2014). Medicinal plants in forests have been used by humans for at least 5 000 years (Petrovska, 2012). The total number of plant species used for medicinal purposes could be as high as 50 000 (Schippmann, Leaman and Cunningham, 2002).

High rates of urbanization and industrialization would seem to distance large populations from the benefits of the forest. However, forests can and do still play a role in supporting their health. In terms of nutrition, some forest products have long contributed to diets even for these populations (e.g. mushrooms, berries). Globalization is contributing to expansion of the array of tropical forest foods reaching consumers, for example palm hearts and insects. Drugs derived from forest plants also have an important role in modern medicine.

Moreover, urban and peri-urban forests, woods and green spaces have considerable and developing potential in enhancing public health, although the economic and societal values of this role are not yet fully understood. In urban contexts, pathways between forests and health include improved environmental quality (enhanced microclimatic conditions) and opportunities for recovery from stress and physical activity (Hartig *et al.*, 2014; Kuo, 2015; Tyrväinen, Bauer and O'Brien, 2019). Growing evidence also suggests that direct contact with nature contributes to a healthier composition of the human commensal microbiota – micro-organisms living mostly in the human gut but also on skin and in other parts of the body, which help their human hosts by providing essential nutrients, metabolizing indigestible compounds and defending against pathogens – and to improved human immune functions (Aerts, Honnay and Van Nieuwenhuyse, 2018) (see Box 1). Non-material or amenity benefits from forests also include spiritual enrichment and cognitive development benefits (Millennium Ecosystem Assessment, 2005).

Much research regarding the health benefits of forests concerns their role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Peri-urban forests offer opportunities for healthy physical activity

in fighting NCDs such as cardiovascular diseases, cancers, chronic respiratory diseases and type 2 diabetes, which are linked to chronic stress, poor diet and other lifestyle factors such as insufficient physical activity (e.g. Nilsson *et al*., 2011; Tyrväinen, Bauer and O'Brien, 2019). NCDs are responsible for almost three-quarters of all deaths globally, the majority of which occur in low- and middle-income countries (WHO, 2018a). Six NCDs are included in the top 10 global causes of mortality (WHO, 2018b): cardiovascular diseases, stroke, chronic obstructive pulmonary disease, Alzheimer's disease, respiratory cancers and type 2 diabetes. The large share of people suffering from these diseases, in both developed and developing countries, not only decreases collective well-being, but also drives up the cost of health care and reduces workforce capability. These health problems often disproportionately affect socio-economically disadvantaged and vulnerable groups and are frequently linked with poor food security and nutrition status, which leads to further health issues. Unplanned and unmanaged population growth and high rates of poverty are associated with malnutrition and increased risk of NCDs. The burden of diabetes in Africa, for example, is expected to increase by 110 percent between 2013 and 2035, and a high proportion (50.7 percent) of diabetes cases are undiagnosed (Hunter-Adams *et al*., 2017). A greater focus on strategies for prevention of NCDs is needed across continents.

It must also be noted that forests, as do all nature areas, pose some risks to human health, including allergic reactions caused by substances from some forest plant and animal species; forest pests and pathogens; the risk of falling limbs or entire trees, especially during storms; the hazards of

Box 1

Forest contact and human immune function: the "biodiversity hypothesis"

The "biodiversity hypothesis" (von Hertzen, Hanski and Haahtela, 2011) proposes that reduced contact with the natural environment and biodiversity leads to inadequate stimulation of human immunoregulatory circuits, with a consequent increase in the occurrence of chronic inflammatory diseases.

It is suggested that microbial input from the natural environment is required to drive immunoregulation: Interaction with the natural environment enriches the composition of the human commensal microbiota, supporting the development of human immune responses (Hanski *et al.,* 2012; Rook, 2013). This may be a crucial benefit of human contact with nature and green spaces. Several studies show that people living closer to natural and biodiverse environments have a more diverse and rich microbiota and less atopic sensitization (Ege *et al.,* 2011; Hanski *et al*., 2012; Ruokolainen *at al.*, 2015, 2017). In addition to enriching the gut microbiome, the biodiversity of the living environment also heavily influences the diversity of microbes on human skin. Thus, factors that alter the health of the skin microbiome have the potential to create a predisposition for non-communicable inflammatory diseases (Prescott *et al*., 2017).

The exposure to beneficial microbiota in the environment during early life has been seen to affect immune system development. Ruokolainen *et al*. (2015) observed that reduced contact of children with biodiversity in natural habitats has adverse consequences on the assembly of human commensal microbiota and its contribution to immune tolerance. A lower prevalence of atopy (the tendency to develop allergic diseases) and atopic diseases in children living in rural areas compared with those living in urban areas may be explained by their greater exposure to soil micro-organisms.

forest work, particularly logging; attack by wild carnivores and venomous animals, such as snakes; contact with or consumption of toxic forest products, such as certain fungi; and frequent wildfire in some forest environments (although these are not all explored in this publication). Some infectious diseases are spread through forest pest vectors, for example Lyme disease and encephalitis borne by ticks (e.g. Tyrväinen, Bauer and O'Brien, 2019). Other forest-associated diseases include malaria, Chagas disease, African trypanosomiasis (sleeping sickness), leishmaniasis and lymphatic filariasis.

With land-use change and forest loss and fragmentation, in many places the boundaries between forest and inhabited areas are becoming less distinct, while globalization and enhanced trade have contributed to making many traditional forest communities less remote from more developed areas. These changes are bringing about new challenges associated with the forest–health–nutrition nexus, including changing diets and erosion of traditional health-related knowledge. An area of intense scrutiny today is the rise of novel zoonotic diseases – diseases that have crossed over from animals and now infect humans. A number of zoonotic diseases that have had dire health and socio-economic consequences, such as malaria, dengue fever, Lyme disease, HIV and Ebola, are almost certainly connected with the loss and fragmentation of forest habitats and increased contact of humans with wild animal products. A "One Health" approach, integrating policies in all sectors touching on human, animal and environmental health, is clearly needed to address such vital issues at the interface between humans, animals and various environments.

2. FOREST CONTRIBUTIONS TO THE HEALTH OF PEOPLE LIVING IN OR NEAR FORESTS

It is estimated that around 820 million people live in tropical forests and savannahs in developing countries (FAO, 2018a), and a major proportion of these depend on forest goods and services for the provision of food, woodfuel, building materials, medicines, employment and cash income. In addition, millions of small forest owners in developed countries manage and benefit from a vast number of forests. When smallholder farmers practising agroforestry or depending on the regulatory and provisioning services of forests and trees in the landscape are included, the number of people who can be considered forest dependent reaches perhaps 2.5 billion (FAO and UNEP, 2020). The role of forests in the health of these populations can be considerable. Forests provide foods and livelihood and income-earning opportunities that contribute to food security and nutrition. They are a source of a wide variety of medicinal products that form the backbone of traditional medicine. They are a source of woodfuel, used to cook food and sterilize water. Furthermore, they are key to the spiritual and mental health of many groups of people, particularly Indigenous peoples, whose cultures are tightly intertwined with the environment in which they live.

DIRECT CONSUMPTION OF FOREST FOODS FOR GOOD NUTRITION AND HEALTH

Nutrient deficiency is a critical challenge to human health. Globally, it is estimated that 820 million people are undernourished (FAO *et al.*, 2019), and over 2 billion people are micronutrient deficient (WHO, 2020). While forest foods may have a small role in terms of calories, they form a critical part of diets commonly consumed by rural, food-insecure populations and add variety to predominantly staple diets. A variety of wild products – including herbs, leaves, fruits, nuts, insects, wild meat, and inland and coastal fishery products – supply energy and carbohydrates, fats, proteins, vitamins and minerals to the diets of around 1 billion people (Burlingame, 2000). Forests provide a significant portion of the daily intake of these nutrients to people living in forested regions (FAO, 2011). A study in four villages in Gabon, for example, revealed that forest foods contributed 82 percent of the protein, 36 percent of the vitamin A and 20 percent of the iron in rural diets (Blaney, Beaudry

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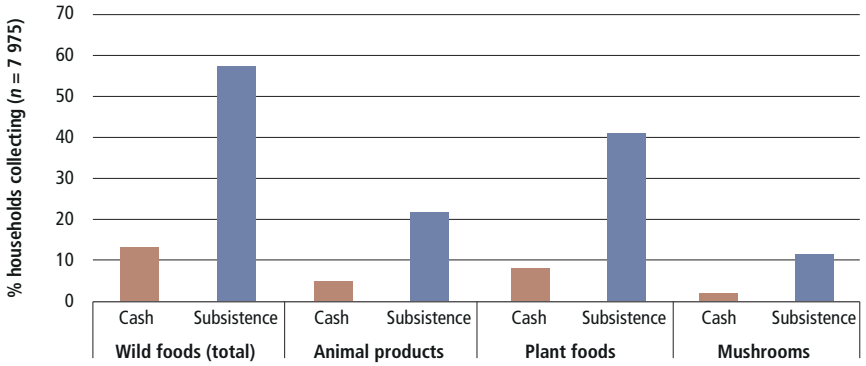
The leaves of *Balanites aegyptiaca*, which grows in drylands of Africa and the Near East, are tasty and nutritious

and Latham, 2009). In some communities with high levels of forest food use, wild forest foods alone are sufficient to meet minimum dietary requirements for fruits, vegetables and animal-source foods (Rowland *et al.*, 2015). The high poverty rates in most forest areas of developing countries makes the contribution of forest food consumption particularly critical for forest communities (Agrawal *et al.,* 2013). Forest foods are especially important in providing a safety net during famine and emergency situations, especially for the poorest and most marginalized populations.

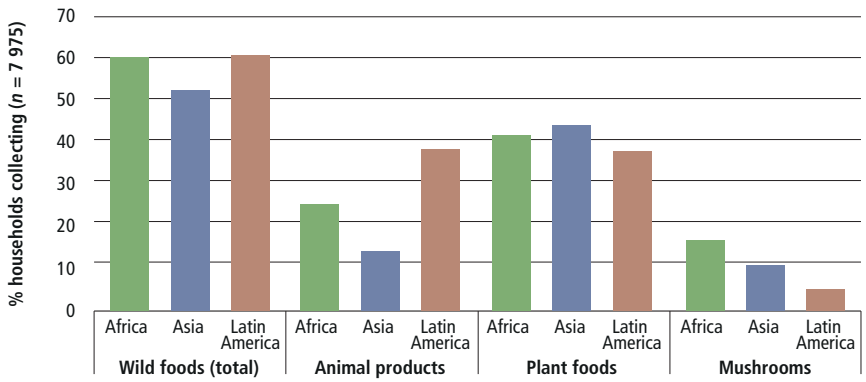
A study analysing household income data from 7 975 rural households in 24 developing countries across three continents found that 77 percent of the households harvested wild food for subsistence (Hickey *et al.,* 2016) (Figures 2 and 3). The study found that in Africa, vegetables, fruits, roots, tubers and spices

FIGURE 2. Predominance of subsistence uses of forest food collected by rural households



Source: Hickey *et al.*, 2016.

FIGURE 3. Proportion of sampled households reporting wild food collection from forest environments, by region



Source: Hickey *et al.*, 2016.

were the most commonly harvested wild plant foods, while mammals, insects, snails and worms were the most commonly harvested animal products; in Asia, bamboo shoots, wild banana, ferns and tamarind were the most commonly harvested wild plant foods, with mammals, amphibians, snails and crustaceans such as crabs and shrimps the most commonly harvested wild animal products.

Forest foods are of particular nutritional (and cultural) importance to Indigenous communities. A study of 22 countries in Asia and Africa, including both industrialized and developing countries, found that Indigenous communities use an average of 120 wild foods per community (Bharucha and Pretty, 2010).

In India, it has been estimated that up to 50 million households supplement their diets with fruits gathered from wildland forests and surrounding bushland (FAO, 2011). In Nepal, individual households collect as much as 160 kg of wild mushrooms per year for direct consumption (Christensen *et al.*, 2008). A study in South Africa found that 62 percent of children (in a sample of 850) supplemented their diets with wild food and 30 percent relied on wild food for over 50 percent of their diet (Shackleton *et al.*, 2010, cited in Agrawal *et al*., 2013). A survey of over 17 000 households in 28 European countries indicated that as many as 25 percent of households consumed forest foods they had gathered themselves (Lovrić, 2016).

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In sub-Saharan Africa, the baobab (*Adansonia digitata*) provides fruits that contain 50 percent more calcium than spinach, are high in antioxidants and have three times the vitamin C of an orange; leaves that are an important source of vitamins and micronutrients; and edible oil from the seeds

Contribution to dietary requirements

Tree products (leaves, nuts and seeds). Edible leaves of wild African trees such as baobab (*Adansonia digitata*) and tamarind (*Tamarindus indica*) are high in calcium and are sources of protein and iron (Kehlenbeck and Jamnadass, 2014, cited in Jamnadass *et al.,* 2015).

The iron content of dried seeds of the African locust bean (*Parkia biglobosa*) and raw cashew nut (*Anacardium occidentale*) is comparable with, or even higher than, that of chicken meat, although absorption of iron from plant sources is lower than from animal sources. Iron absorption is enhanced by the intake of vitamin C, which is found in large amounts in many tree fruits (Jamnadass *et al.,* 2015).

Fruits from a number of wild indigenous fruit trees have a high content of vitamins and minerals (Table 1) and can contribute to the micronutrient supply of local communities year round, even during seasonal food shortages (Vinceti *et al.,* 2013). For example, the consumption of 40 to 100 g of *Grewia tenax* berries could supply almost 100 percent of the daily iron requirement of a child under the age of eight years. Such forest fruits also have high sugar content, which makes them important sources of energy. The fruits of *Dacryodes edulis* and the seeds of *Irvingia gabonensis, Sclerocarya caffra* and *Ricinodendron rautanenii* all have higher fat content than groundnuts (peanuts).

Wild meat and insects. Bushmeat and artisanal fisheries contribute greatly to meeting dietary protein requirements of households close to forests. In Central Africa, for example, they account for 85 percent of the total protein intake of

TABLE 1. Nutrient contents of selected African indigenous and exotic fruits per 100 g edible portion

Species	Energy (Kcal)	Protein (g)	Vitamin C (mg)	Vitamin A (RE*) (µg)	Iron (mg)	Calcium (mg)
Indigenous fruits						
Adansonia digitata	327	2.5	126–509	0.03–0.06	6.2	275
Dacryodes edulis	263	4.6	19		0.8	43
Grewia tenax		3.6			7.4–20.8	610
Irvingia gabonensis (kernels)	697	8.5			3.4	120
Sclerocarya birrea	225	0.7	85–319	0.035	3.4	35
Tamarindus indica	275	3.6	11–20	0.01–0.06	3.1	192
Ziziphus mauritiana	184	0.4	3–14	0.07	0.8	23
Exotic fruits						
Guava (*Psidium guajava*)	68	2.6	228	0.031	0.3	18
Mango (*Mangifera indica*)	65	0.5	28	0.038	0.1	10
Orange (*Citrus sinensis*)	47	0.9	53	0.008	0.1	40
Pawpaw (*Carica papaya*)	39	0.6	62	0.135	0.1	24

* RE = retinol equivalents.
Source: Vinceti *et al.,* 2013.

forest people (FAO, 2017a). In the same region it has been estimated that hunting provides 30 to 80 percent of the protein intake of rural households and nearly 100 percent of animal protein in villages within forests (Koppert *et al.,* 1996 and Nasi *et al.,* 2011, cited in FAO, 2017a). In Madagascar, the loss of access to wild meat was seen to lead to a 29 percent increase of children's anaemia, and the increase was even greater in the poorest households (Golden *et al*., 2011, cited in FAO, 2018a).

Small insects, caterpillars and snails are also important sources of animal protein and fat. Forest caterpillars, for example, contain even more protein, fat and energy than meat or fish (Pierce Colfer, 2012). Furthermore, 100 g of cooked caterpillars provide more than 100 percent of daily vitamin and mineral requirements (Vantomme, Göhler and N'Deckere-Ziangba, 2004). Insects have always been a part of human diets and are currently a cheap and accessible source of nutritious food, supplementing the diets of approximately 2 billion people, mainly in Asia, Africa and Latin America. Worldwide, humans consume more than 1 900 insect species, of which the most common are beetles (Coleoptera) (31 percent), caterpillars (Lepidoptera) (18 percent) and bees, wasps and ants (Hymenoptera) (14 percent) (van Huis *et al*., 2013).

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Palm weevil larvae (grubs) are an important source of protein in the Amazon and Congo basins and Southeast Asia (Limoncocha Biological Reserve, Ecuador)

Other forest products. Cassava, taro, yam and sweet potato are among the major sources of carbohydrates extracted from forests and consumed directly. Resins, saps, gums and honey are rich in protein and minerals. Mushrooms are rich in minerals, vitamins and amino acids. Wild vegetables contribute important vitamins and minerals. In the Mekong Delta of Viet Nam, for instance, wild vegetables were seen to contribute 38 percent of the vitamin A, 35 percent of the vitamin C, 30 percent of the calcium and 17 percent of the iron consumed by women (Ogle *et al.,* 2001).

Table 2 provides examples of how specific non-wood forest products (NWFPs) can help address particular nutritional deficiencies.

Dietary diversity

Forest foods also contribute to dietary diversity, and a more diverse diet increases the diversity of the gut microbiome for improved health (Heiman and Greenway, 2016; Singh *et al.*, 2017). A statistically significant positive association has been found between the dietary diversity of children in developing countries and the tree cover in their communities (Ickowitz *et al.,* 2014). A study of data from 43 000 households across 27 countries in Africa found that the dietary diversity of children who were exposed to forests was at least 25 percent higher than that of children who were not (Rasolofoson *et al.,* 2018). In the East Usambara Mountains of the United Republic of Tanzania, children and mothers in households that had more tree cover close to their homes and that ate more foods from forests were found to have more diverse diets (Powell, Hall and Johns, 2011), while children living in deforested areas in Malawi were seen to have less diverse diets than children living in areas where forests remained intact (Johnson, Jacob and Brown, 2013).

TABLE 2. Use of non-wood forest products in addressing nutritional deficiencies

Common nutritional problem	NWFPs useful in solving these problems
Protein–energy malnutrition, causing reduced growth, susceptibility to infection, changes in skin, hair and mental facility	Nuts, seeds (e.g. *Geoffroea decorticans*, *Ricinodendron rautanenil*, *Parkia* spp.), palm oil, baobab (*Adansonia digitata*) leaves, small animals (snails, insects, caterpillars)
Vitamin A deficiency, which can cause blindness and, in extreme cases, death	Green leaves (e.g. *Pterocarpus* spp., *Moringa oleifera*, *Adansonia digitata*), yellow and orange fruit (e.g. bush mango), resins, unrefined palm oil, the gum of *Sterculia* spp., bee larvae and other animal food
Iron deficiency, causing anaemia, weakness and susceptibility to infection, especially in women and children, and increased risk of low-birthweight babies	Bushmeat, green leaves (*Leptadenia hastata*, *Adansonia digitata*), seeds (*Parkia biglobosa*, *Anacardium occidentale*), *Grewia tenax* berries, mushrooms
Niacin (vitamin B3) deficiency, which may cause dementia, diarrhoea and dermatitis; common in zones with a maize-based diet	Baobab (*Adansonia digitata*), *Boscia senegalensis* and *Momordica balsamina* fruit, *Parkia* spp. seeds, bush mango (*Irvingia gabonensis*), acacia (*Acacia albida*)
Riboflavin (vitamin B2) deficiency, which causes skin problems; common in those with a rice-based diet	Green leaves, especially *Anacardium* spp., *Sesbania grandiflora* and *Cassia obtusifolia*; insects
Vitamin C deficiency, which increases susceptibility to disease	Fruit of *Adansonia digitata*, *Sclerocarya caffra* and *Ziziphus mauritiana*; leaves (e.g. *Cassia obtusifolia*); gum of *Sterculia* spp.

Source: Based on Falconer and Arnold, 1988; FAO, 2017a.

FOREST-BASED INCOMES SUPPORTING HUMAN NUTRITION AND HEALTH

Income can influence health outcomes in several ways, both by providing for the material conditions necessary for survival, and by affecting social participation and the opportunity to control life circumstance (Marmot, 2002). Income from the forest sector also helps people buy food, which can contribute to individual and household food security, nutrition and health. A study in the Democratic Republic of the Congo, for instance, found that a large part of forest product marketing by women was intended to support health. In Phalanga village, for example, women invested 48 percent of their cash income in nutrition, and 24 percent of proceeds from the sale of forest products was spent on health care (Endamana *et al.*, 2015).

Forest income can be associated with the production and sale of wood and non-wood forest products and the provision of forest services for local, regional, national or international markets. Employment can be formal or informal, casual, contractual or permanent. Technology and value addition processes also affect the share of income that local people receive, eventually influencing their ability to buy food and medicines and to obtain health care.

The forest sector has created some 54 million full-time equivalent jobs, including 13 million in the formal sector (about 0.4 percent of the global workforce) and 41 million in the informal sector (FAO, 2014). In some countries, small and medium-sized forest enterprises may account for up to 80 to 90 percent of employment in all forest enterprises, formal and informal (World Bank, 2016).

Enterprises producing solid wood products are the largest formal forest-sector employers at the global level and in all regions except Africa, employing about 5.4 million people in all. These are followed in importance by pulp and paper enterprises and then by producers of roundwood (FAO, 2014).

A study of the contribution of the forest to cash income in eight villages in Uganda (Shepherd, Kazoora and Mueller, 2013) indicated that fuelwood and charcoal were by far the most important products, accounting for 36 percent of all cash sales, followed by building materials (including poles and thatching materials, as well as fired clay bricks), which accounted for 30 percent. Cash was also obtained through the collection of various forest foods, fibre and medicines. Timber was the least important source of cash income. Location and access to markets made a difference in villagers' ability to sell forest products. Men sold a higher percentage of forest products than women did in both remote and less remote villages.

Non-wood forest products, including among others forest foods, medicines and cosmetics, are often an important source of income in developing countries. The people of the Sahel obtain almost

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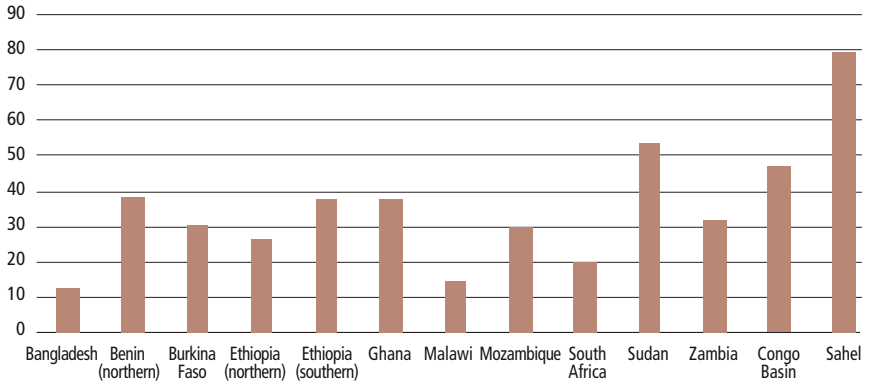
Brazil nuts from the Bolivian Amazon provide not only nutritional benefits, but also income to support the nutrition and health of forest communities

FIGURE 4. Percentage of household income from non-wood forest products



Source: FAO, 2018a.

80 percent of their household income from NWFPs; these products provide more than 50 percent of household income in the Sudan and 45 percent in the Congo Basin (Figure 4). NWFPs contribute to economic well-being not only for their collectors and sellers but for others involved along the value chain. For example, eight West African countries alone exported 350 000 tonnes of shea butter in 2008, with an export value equivalent to USD 87.5 million (at 2008 prices). The shea butter value chain, including collection, processing and marketing of shea nuts, provides jobs for some 4 million to 5 million women, contributing about 80 percent of the total income of women-headed households (Ferris *et al.,* 2001; FAO, 2011).

MEDICINES FROM THE FOREST

Diseases pose a particular challenge to the survival of forest people. Transmissible diseases are particularly diverse in forest ecosystems, especially moist and hot tropical ecosystems (Dounias and Froment, 2006), and forest communities are often remote from health services.

WHO estimates that at least 80 percent of the world's population depends on traditional medicine to meet primary health care needs (Azaizeh *et al*., 2003). In all major tropical regions, local knowledge of medicinal plants constitutes a major part of traditional health care systems, such as Ayurvedic medicine in India. These traditional health care systems are crucial for sustaining lives, particularly in areas where formal health care systems are absent (FAO, 2006).

WHO (2019) defines traditional medicine as the "sum total of the knowledge, skill, and practices based on the theories, beliefs, and experiences indigenous to different cultures, whether explicable or not, used in the maintenance of health as well as in the prevention, diagnosis, improvement or treatment of physical and mental illness". Such systems contribute to the resilience of peoples associated with forests around the world, often as the most available, accessible, affordable and sometimes culturally acceptable source of health care. For example, it is estimated that at least 1 billion people in developing regions use herbal remedies to treat children's diarrhoea (FAO, 2014). The custodians of traditional knowledge and expertise regarding medicinal plants, their transformation into safe and effective products and their use in household health are most often women (FAO, 2018b).

Data on the exploitation, management, consumption and trade of medicinal plants are deficient, however.

Baishya, Sarma and Begum (2013) report that the forests in the state of Assam, India, are known to host about 900 species of medicinal herbs and plants. Forest plant species are commonly used in India to treat snake-bite, asthma, jaundice, dropsy, gynaecological problems, piles, elephantiasis, bronchitis, rheumatism, leprosy, diabetes, cancer, pneumonia, paralysis, pharyngitis, ulcers, dysentery, cough, skin diseases, fever and lactation insufficiency (Baishya, Sarma and Begum, 2013; Padal, Chandrasekhar and Vijakumar, 2013).

Randrianarivony *et al*. (2017) report the use of 235 taxa to treat 76 diseases in southwestern Madagascar. Among them, the most cited uses were in pregnancy, childbirth and post-partum care and in treating disorders of the digestive system.

The most commonly used plant parts for medicinal purposes are the leaves (Padal, Chandrasekhar and Vijakumar, 2013), but forest products with common medicinal uses also include cola nuts, coffee (caffeine) and chocolate.

In a study of two districts in western Ghana (Ahenkan and Boon, 2011), 90 percent of a surveyed population used plant-based medicines to cure ailments such as malaria, typhoid, fever, diarrhoea, arthritis, rheumatism and snake-bite. Approximately two-thirds of the respondents had traditional knowledge of NWFPs used to prepare remedies by themselves.

In Central Africa, leafy vegetables, slightly unripe fruit such as jujube, acacia pods and tamarind flowers are used in the treatment of diarrhoea and haemorrhoids; leafy vegetables, ripe fruit, and the bark and roots of acacia are used for constipation and stomach ache; custard apple, various barks such as acacia or kola nut and karité are used to treat parasites; and bark (especially acacia) and honey are used to treat bone aches, coughs and asthma (FAO, 2017a).

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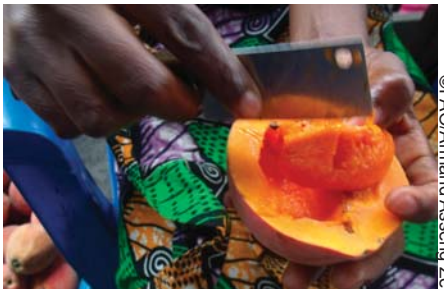
A Maasai tribesman in the United Republic of Tanzania cuts bark off a mkunde kunde tree, which is ground into a paste and used to treat abdominal pains in humans, as well as to deworm animals



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The nut or seed of *Garcinia kola* (bitter kola) is used in Central Africa as a purgative, antiparasitic and antimicrobial and is adopted in the treatment of bronchitis, coughs and throat infections and to prevent and relieve colic

Many wild edible mushrooms also have medicinal properties, including as antibacterials (Singha *et al.*, 2017). A study in northern India identified 33 mushroom species used by local herbalists (either alone or with other herbs) to treat various conditions ranging from blood, heart and respiratory ailments to arthritis and diseases of the nervous and urogenital systems (Malik *et al*., 2017).

In China, almost 5 000 of over 26 000 native plant species (19 percent) are used as drugs (Duke and Ayensu, 1985). Traditional Chinese medicine also includes many preparations obtained from animals (such as tiger bones, antelope, buffalo or rhinoceros horns, deer antlers and bear or snake bile), often in combination with medicinal herbs, although their clinical efficacy has not been well studied (Still, 2003). Such products can command very high prices (Box 2) but are ethically and environmentally controversial (as discussed in the section on sustainable wildlife management in Chapter 5).

Indeed, forest-based medicines are often a source of income for forest dwellers. Herbal medicines alone are worth USD 189 million dollars annually to rural Ugandans – nearly 60 percent of the national health budget (Shepherd, Kazoora and Mueller, 2013). Some forest-based medicinal products are traded internationally or form the basis of commercial pharmaceuticals (see Chapter 3).

These values call for conservation efforts to maintain the full diversity of species used in alleviating human suffering, both now and in the long term.

Box 2

Chinese caterpillar fungus, a medicinal non-wood forest product worth its weight in gold

The caterpillar fungus *Ophiocordyceps sinensis* (also known as *Cordyceps sinensis*), collected in the Himalayan region of Bhutan, China and Nepal and greatly prized in traditional Chinese medicine, is valued at USD 20 000 to 40 000 per kilogram. The parasitic fungus grows in caterpillars, consuming and killing its hosts. The fungus contains more than 20 bioactive ingredients, to which more than 30 bioactive properties have been attributed, including immunomodulatory, antitumor, anti-inflammatory, and antioxidant activities. It has exhibited activity against arteriosclerosis, depression and osteoporosis activities, and may also improve endurance, cognition and memory (Lo *et al.,* 2013).

Collection of *O. sinensis* also makes important contributions to household income in the areas where it is collected. In 2011, the fungus contributed 40.5 percent of total NWFP revenue in Nepal, with the sale of 474 kg of fungus bringing USD 6 million to 8.5 million. In certain areas of the country, income from the sale of the fungus contributes more than half of total household income (USD 1 844 per year) (Shrestha and Bawa, 2014).

WOODFUEL: A SOURCE OF HEALTH BENEFITS AS WELL AS RISKS

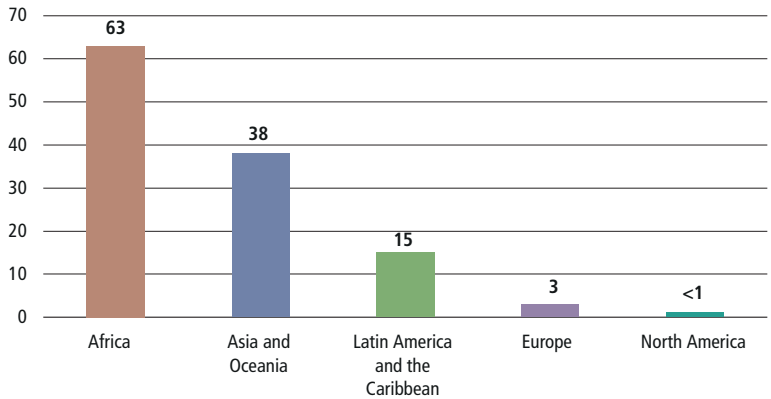
Use in cooking food and sterilizing water

It is estimated that over 75 percent of rural households in low- and medium-income countries depend primarily on woodfuel for cooking (as compared with around 20 percent of urban households in these countries, although urban households are more likely to use charcoal, while rural households are more likely to use fuelwood). The reliance is greatest in Africa, Asia and Latin America and the Caribbean, where 98 percent of the world's 795 million undernourished people live (Figure 5) (FAO, 2017b). Woodfuel is particularly important for the poorest people, for whom it is often the cheapest, most readily available and most easily accessible source of fuel. It thus has an essential role in human health, as cooking is necessary for the utilization of many foods, as well as for boiling and sterilizing water.

Cooking food can improve nutritional quality and uptake. It increases the bioavailability of certain micronutrients, such as beta-carotene (in such foods as tomatoes, carrots and sweet potatoes) and lycopene (an antioxidant found in tomatoes) and allows iron and other minerals to be better absorbed by the body. Many foods with high nutritional value, such as beans and cereals – which are especially important in the diets of people who cannot afford animal protein – require long cooking times. Cooking also makes food easier to chew, thereby making digestion more efficient. Cooking and reheating food also increases food safety by eliminating dangerous micro-organisms and toxic components. Woodfuel is also used in smoking and drying food, to preserve it and prolong its shelf life beyond the growing season. In addition to household use, woodfuel is also used for commercial food preparation in schools, restaurants, street stalls and small-scale food processing industries such as tea drying and fish smoking (FAO, 2017b).

Untreated drinking-water may contain parasites and pathogens that cause diarrhoea, typhoid or dysentery. In 2015, an estimated 663 million people globally had no access to clean, safe drinking-water and had to source water from unprotected wells, springs and surface water. Some forest communities obtain their water from unreliable water sources (including river water and boreholes) and as a result are vulnerable to water-borne diseases. Boiling

FIGURE 5. Percentage of households relying on woodfuel for cooking, by region



Source: FAO, 2017b.

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Cooking with woodfuel, Cuyabeno, Ecuador

is the most common method for treating drinking-water, used by around 20 percent of people in developing countries. An estimated 1.38 billion people in Africa, Asia, Latin America and the Caribbean and Oceania treat drinking-water by boiling it, and about 765 million people (10.9 percent of the global population) use woodfuel for this purpose (FAO, 2017b). Clean water is also needed to wash food, for general household hygiene and for treating wounds.

Health-related consequences of woodfuel use

Smoke from woodfuel can pose a serious human health risk, especially if woodfuel is used indoors without proper ventilation and burned with inefficient stoves. Household air pollution is the single most important environmental health risk worldwide (FAO, 2017b). WHO estimates that around 3 billion people, mostly poor and living in low- and middle-income countries, use polluting fuels from biomass (wood, dung, crop residues and charcoal), coal and kerosene to cook and heat their homes using open fires and simple stoves (WHO, 2018d). Smoke from solid fuels including coal and biomass is associated with close to 4 million deaths each year from pulmonary diseases, strokes, lung cancer and coronary heart disease (WHO, 2018d), and it can also cause blindness. Malnourished and nutrient-deficient people are more susceptible to diseases related to poor air quality (Stloukal *et al.*, 2013). Women and children are particularly exposed to risks from cooking smoke. Other health risks from woodfuel use include burns and injuries.

Woodfuel use also contributes to climate-related risks, including emissions of carbon dioxide from unsustainable wood harvesting and of methane and black carbon (the most light-absorbing component of particulate matter) from incomplete combustion, which all have indirect ramifications for human health (see Chapter 4). However, woodfuel has a lower carbon footprint than fossil fuels when managed sustainably.

In some cultures, the smoke from domestic fuel use is believed to have a benefit in repelling mosquitoes, which carry diseases such as malaria. However, while the burning of particular aromatic plants may have some effectiveness in repelling mosquitoes, WHO (2008) found that cooking smoke had no effect on the indoor abundance of African malaria vectors. In any case, most domestic cooking is done outside the peak biting times for malaria vectors (FAO, 2017b).

CULTURAL, SPIRITUAL AND MENTAL HEALTH

Well-being is a condition not only of individuals, but also of the broader community. For people living in and near forest areas, the forest often has a cultural significance that is key to the spiritual health of individuals and communities and, indeed, underlies local efforts to protect nature and conserve forests. Forests that are considered sacred account for an estimated 5 to 8 percent of global forest area (McFarlane *et al.*, 2019). Respect for sacred sites or ancestors may be linked to concerns for passing on biodiverse natural resources and customary tenure rights to future generations, in turn helping to protect well-being, identity and kinship (Fritz-Vietta, 2016). In northern Cambodia, for example, monk-led community conservation of 18 000 ha of rare lowland evergreen forest has been motivated by reverence for the example and teaching of Buddha and has been focal in post-Khmer Rouge community recovery (ARC, 2010). Other examples

include sacred groves in the Western Ghats in India and Bhutan and church forests of Ethiopia. Portions of these ecosystems remain intact today in part because they have been considered sacred by Indigenous people (Lowman and Sinu, 2017). In such contexts the well-being of the forest is associated with enhanced collective and community well-being in a large sense, as Indigenous people typically establish a link between individual and community health and between healthy land and healthy people. The concept is illustrated by the North American Algic language term *miyupimaatisiiun* – meaning "being alive well" – which defines health not only in terms of individual physiology, but also in terms of social relations, cultural identity and relation to the land (Asselin, 2015).

Forest degradation and deforestation have been observed to cause negative mental health effects for Indigenous and other rural populations. Among Pygmy tribes in the Congo Basin, for example, the inability to obtain culturally important forest products such as bushmeat and medicine has been seen to cause psychological unrest and to have negative impact on mental well-being, regardless of the abundance of non-traditional alternatives (Ohenjo *et al*., 2006; Dounias and Ichikawa, 2017). Deforestation leads not only to difficulties in collecting locally important NWFPs, but also to the deterioration (or disappearance) of landscapes and sites of personal and community significance (e.g. McFarlane *et al*., 2019). These environmental changes have been seen to cause psychic or existential stress and loss of identity (e.g. Albrecht *et al*., 2007), which can be profound and amplified by disempowerment and marginalization.

RECOMMENDATIONS: HOW TO PROMOTE GOOD HEALTH OF FOREST PEOPLE

Policy and institutions are important in shaping forest contributions to food and health (Adhikari, Ojha and Bhattarai, 2016; Khatri *et al*., 2017). Above all, the contribution of forests to the health, nutrition and food security of local populations depends on preventing the loss of forests and trees and maintaining their integrity through best practices of sustainable forest management, while ensuring that the harvesting of forest products, including foods and medicines, does not deplete the resources. Sustainable forest management in turn depends on secure land tenure rights, which enable local people's access to forests for their livelihoods and health-giving products, providing a strong incentive to conserve forest resources. In this regard, indigenous knowledge and practices that have allowed forests to be used sustainably over time can provide a sound basis for improving forest management.

Forest management approaches that support human health will vary depending on the context, traditions, culture and values of the communities. Some forest communities depend on the non-intensive use of extensive areas of forest, often within protected areas. Restricting their use of the forest can be detrimental to their health because of the loss of the varied physical, socio-economic, cultural and spiritual benefits described above. Therefore, it is essential to harmonize environmental conservation, socio-economic and cultural targets (Pyhälä, Orozco and Counsell, 2016).

The hunting and trade of wild animals for meat or for traditional medicine poses special concerns – related not only to trade in endangered species but also to the risks of transmission of zoonotic diseases (see Chapter 4).

Conservation initiatives should also not overlook the spiritual value of forests, as failing to take cultural values into consideration may have adverse effects on the individual and societal health of forest dwellers (FAO and UNEP, 2020). Sacred forests house the majority of biodiversity for billions of people in Africa and Asia, and their stewardship has been ensured over time through the respect and leadership of religious stakeholders (Lowman and Sinu, 2017). Their protection represents a unique conservation success in rather

difficult conditions, especially in developing countries. Custodians of sacred sites and other holders of spiritual values are natural allies in nature conservation and could facilitate local people's acceptance of necessary conservation measures. It is also vital to value indigenous forest knowledge in forest planning and management (Asselin, 2015).

Similarly, it is essential to promote livelihood and income generation opportunities for communities living in or near forest areas. Promoting the sale of sustainably harvested forest products, including edible and medicinal products, can enhance the incomes of the poorest people and thus their health, food security and nutrition. In Nepal, for example, the poorest people collect and consume a diverse range of edible products from the forest (such as mushrooms; the seeds of the butter tree, *Diploknema butyracea*, used for their oil; and wild fruits and vegetables), but many do so only for their own subsistence. With support to facilitate value addition, in one district the income received from the sale of bay leaf increased by almost 400 percent (Bhattarai *et al*., 2009). Nature-based tourism enterprises, which are often small scale, complement more traditional resource uses such as farming, forestry and fisheries and can play an important role in diversifying rural livelihoods and creating jobs (Bell *et al*., 2009; Fredman and Tyrväinen, 2010).

Management of edible insects as a commercial food resource has great potential. However, overharvesting can pose conservation and food security issues. Insect rearing for food and feed is being explored to alleviate pressure on wild populations and to support food security at a larger scale. Rearing insects requires minimal technical or capital expenditure and only basic equipment. Small-scale insect rearing is already well established in Thailand and Viet Nam. More recently, Kenya and Uganda have successfully established cricket and grasshopper farming models. Farming edible insects not only offers nutritional and economic value, but also provides entrepreneurship opportunities and relieves pressure on limited resources such as land, soils, water and energy. For instance, it is much more environmentally friendly to produce protein from yellow mealworm (*Tenebrio molitor*) than from beef (van Huis *et al.,* 2013).

Insect gathering from the wild continues to supplement diets and diversify livelihoods in large parts of sub-Saharan Africa, Asia and Latin America. Insects are often gathered, processed and sold by the poorest members of society, who tend to be women and landless people in urban and rural areas. If harvested sustainably, insect gathering can directly improve diets and provide cash income, for example through the sale of excess production as street food (van Huis *et al*., 2013).

It is not possible to address the forest–health–nutrition nexus without taking gender aspects into consideration (FAO, 2018b). In developing countries, it is mainly women who control the use of natural resources for nutrition and health: It is women who collect and sterilize water, collect fuel and provide food and medicine for their households. Women are custodians of traditional knowledge on local biodiversity, how to transform it into edible and medical products and how to manage it sustainably. It is also women and children who suffer the most from indoor

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At a weekly market in Orissa, India, tribal women sell edible forest products such as tubers and bamboo shoots

Box 3

Impact of COVID-19 on forest communities, and social protection measures to assist them

Depleted forest biodiversity, wildlife trade, deforestation and forest degradation can create enabling conditions for the transmission of dangerous novel pathogens to humans. The mismanagement of forested landscapes and their wildlife has been associated with the spread of viruses and other pathogens that threaten humans including Ebola, HIV and Zika virus (see Chapter 4). The maintenance of healthy forests in landscapes needs to be an integral part of strategies to reduce risks of epidemics.

The COVID-19 pandemic, and the control measures taken to stem it (e.g. movement restrictions, school closures, lockdowns), will have severe economic consequences in most sectors, markets and communities. Although it is not yet known how widely the COVID-19 contagion has spread to forest communities, both the health and economic effects are likely to be magnified for them because of their often-fragile livelihoods. Women-headed households and Indigenous, landless and other marginalized peoples are particularly susceptible. The remoteness of forest communities does not necessarily protect them from the disease. Contagion may be spread, for example, by returning migrant labourers fleeing COVID-19 and loss of work in urban areas.

The recent Ebola outbreak in West Africa and its impact on agricultural production and rural welfare give an idea of the effect that COVID-19 may have on forest communities in developing countries. That outbreak resulted not only in direct and indirect financial and health-related costs but also in reduced participation in the labour force through efforts to avoid contagion, market closures and limited movement.

Community isolation, movement restrictions and curfews to reduce exposure to COVID-19, whether self-directed or government implemented, have the effect of detaching smallholder farmers, foragers, hunters and forest-product value-chain workers from their markets, raising the risk of increased food insecurity and malnutrition. The abrupt loss of income may prove catastrophic for poor households, including informal and formal forest workers. Movement restrictions, decreased in-country trade and economic decline may also jeopardize supplies of fuelwood and charcoal, needed for purifying water and cooking. In struggling economies, falling back on forest safety

▶▶

pollution related to unsafe woodfuel use for cooking. Nevertheless, women rarely have a significant and proportionate voice in decision-making. In efforts to improve the health and nutrition of forest communities, it is important to recognize women's roles and to ensure a gender-sensitive and inclusive approach. Women's empowerment and rights over forest resources lead to improved nutrition and health outcomes, because women tend to use their income from forest activities to feed their families (Arora-Jonsson *et al.*, 2019). Granting women a greater voice could perhaps also help raise the profile of health and nutrition issues in forest-related decision-making.

Many of the world's forest people, including many Indigenous peoples, have high rates of poverty and food insecurity and are especially vulnerable to infectious diseases owing to lack of access to health and nutrition information and health facilities, including testing services, in the remote regions where they live (CSD, CFR-LA and AIFFM, 2020). However, as they have lived and flourished in close proximity to forest pathogens for generations, forest communities have adopted many methods to protect themselves from the risks of infectious diseases. These include their vast traditional knowledge of locally sourced remedies from the forest, natural resource use practices that

nets can lead to natural resource overharvesting, forest degradation and deforestation. Deforestation risks may be heightened as the restrictions impede conservation efforts, such as monitoring and enforcement of regulations in protected forests.

Governments around the world have been quick to implement social protection responses to the pandemic, i.e. policies and programmes that protect and promote livelihoods to address economic, environmental and social vulnerabilities to food insecurity and poverty. Social protection can protect incomes, prevent negative coping strategies, support productive activities, promote access to health care and safety measures, and incentivize compliance with social distancing measures. Governments can ensure that forest communities benefit from social protection responses to the COVID-19 pandemic by:

- formulating responses through participatory processes that include forest communities and organizations that work with them, such as non-governmental, community-based and forest producer organizations;
- ensuring that targeting is inclusive and based on the best available information, identifying all vulnerable groups;
- using accessible media and languages to communicate essential public health information to forest communities and to inform them of their entitlements and when and in what form assistance will be made available to them;
- tailoring responses to local characteristics, e.g. using cash transfers to safeguard food security and incomes efficiently, using in-kind food transfers to offset the closure of vital food markets and movement restrictions where markets, transport and communication infrastructure are weak, and designing labour market programmes to account for the high informality in forest communities;
- safeguarding conservation efforts (e.g. through remote monitoring by drone or helicopter), as allowing the crisis response to sideline efforts to oversee and manage forests could raise the risk of deforestation, thus undermining the livelihoods of forest communities.

Source: FAO, forthcoming; CSD, CFR-LA and AIFFM, 2020.

maintain biodiversity-rich ecosystems and a wide range of traditional cultural rituals and taboos that together can reduce the spread of infections. For instance, food taboos in a Brazilian forest hold that fish with certain culturally defined characteristics should be avoided by people in poor health; these fish could be risky from a medical point of view because they may be toxic or rot quickly (Pierce Colfer, Sheil and Kishi, 2006). In another example, Karen people living in a heavily forested region of Southeast Asia are reviving their ancient Kroh Yee (village closure) ritual to combat COVID-19, after having used the same ritual to control a cholera outbreak 70 years ago (IMN, 2020).

Indigenous health systems (including those for mental and spiritual health) should be valued, studied and used to improve health care.

Severe health shocks can heighten the vulnerability of forest communities. The COVID-19 pandemic is the immediate example, but it is unlikely to be the last. These communities require the support of appropriate social protection measures (Box 3). Poor access to health care can create stress and fear, especially in a public health emergency. In the COVID-19 pandemic, or in any public health emergency that requires individuals to modify their behaviour, information must be accessible to all citizens (FAO, forthcoming).

3. ROLE OF FORESTS IN THE HEALTH OF URBAN POPULATIONS AND INDUSTRIALIZED SOCIETIES

More than half of the global population lives in urban areas (55 percent in 2018), and this proportion is expected to increase to 68 percent by 2050 (UN, 2019). These vast urban populations are exposed to stresses such as noise, air and water pollution and other aspects of poor environmental quality. Poor urban planning, with often unhealthy living conditions, accentuates stress and can also reduce access to healthy food options (e.g. WHO and UN-Habitat, 2016). In Africa, for example, rapid urban population growth and high poverty rates have been associated with increased risk of NCDs (Hunter-Adams *et al*., 2017).

Forests provide not only material products, but also non-material services. While societies distant from the forest have benefited from the material products as long as there have been cities, the rapid increase in urbanization and problems arising from the stresses of modern life create new demands for forests' health-related services (Chun, Chang and Lee, 2017; Franco, Shanahan and Fuller, 2017; Li *et al*., 2007).

Urban and peri-urban forests and trees help mitigate many of the drawbacks of living in urban areas: They buffer noise; reduce the urban heat island effect, which can be lethal during heat waves; and provide green space for exercise, recreation and recovery from stress (FAO and UNEP, 2020). Furthermore, by capturing particulate matter of up to 10 microns in diameter, trees absorb pollution from traffic and industry, thus helping to shield against respiratory disease (Manes *et al*., 2016; Yang *et al*., 2005; Nowak, Crane and Stevens, 2006). Activities in the forest have been seen to provide both preventive and therapeutic health benefits (Kaplan, 1993; Tyrväinen, Bauer and O'Brien, 2019). Extensive research provides empirical evidence that use of forest or viewing forest scenes contributes to reducing stress and promoting more positive moods and feelings, and it may facilitate recovery from illness by enhancing immune system function (Jeon, Yeon and Shin, 2018).

A literature review by Markevych *et al*. (2017) concludes that long-term exposure to residential parks, gardens and forests is beneficial to health for urban populations studied in relatively high-income countries. These authors cite studies associating nature exposure with benefits related to general health, obesity, birth weight,

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Cycling in the forest for good health, United Kingdom

childhood behavioural development and mortality, although not all studies concur with these conclusions. The results seem to depend on people's behaviour, preferences, and social and cultural attitudes regarding the use of nature, as well as on the supply, quality and accessibility of natural areas. Nature exposure appears to reduce income-related inequality in health status; it has been seen to provide greater benefits for groups with lower socio-economic status, perhaps because it may mitigate factors accounting for their generally higher rates of disease (Maas *et al*., 2006; Mitchell and Popham, 2008).

Nature-based tourism is one of the fastest growing sectors of the world's largest industry, and its popularity derives in part from its role as a source of health benefits (e.g. Bell *et al*., 2009; Balmford *et al*., 2009). To take fuller advantage of the benefits of nature, an increasing number of economically well-off people in developed and developing countries are opting to live at least part time in forested areas, in what has been termed "amenity migration" (Gosnell and Abrams, 2011).

FOREST PRODUCTS AND HEALTHY DIETS

The value of forest foods as a nutritional resource is not limited to the developing world. A survey of over 17 000 households in 28 European countries showed that almost 92 percent had consumed wild forest products in 2015; 82 percent of them purchased these products from a shop, while 25 percent were involved in direct gathering (Lovrić, 2016). A large variety of game (38 species), mushrooms (27 species) and vascular plants (81 species) are collected and consumed in Member States of the European Union. Overall, more than 100 million European Union citizens consume wild food (Schulp, Thuiller and Verburg, 2014). Wild game and other forest products are also commonly consumed in North America. Some forest foods are widely traded. The global market for edible mushrooms, many of which are collected from forests, has a value estimated at USD 42 billion per year (Willis, 2018, cited in FAO and UNEP, 2020).

Urban people in more prosperous economies are also showing a growing interest in forest foods less commonly consumed in their cultures, as illustrated by the appearance of products from tropical forest species such as the açai palm (*Euterpe oleracea*) and the baobab tree (*Adansonia digitata*) on supermarket shelves or in the recipes of contemporary chefs around the world. In recent years, consumption of insects as food has also become environmentally, socially and economically accepted in some European countries such as Belgium, Finland and the Netherlands, where insects have not been part of traditional diets (FAO and UNEP, 2020). Food products containing insects include snacks (e.g. protein bars), bakery products (e.g. flour), sauces and seasonings, in addition to whole or dry insects, now readily available even in large grocery chains in Canada, the United Kingdom and the United States of America (van Huis *et al*., 2013).

Some forest products from the developing world also show potential for the global market in health-promoting foods. Jamnadass *et al.* (2010, 2015) describe a public–private partnership for the domestication of *Allanblackia* spp.,

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Finland's clean and unpolluted boreal forests are full of wild berries and mushrooms, which can be picked freely by anyone under the "everyman's right" law **(see p. 37)**

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Restaurant staff prepare dishes with wild Sahelian foods at a gastronomic restaurant in Niamey, the Niger

found wild in the humid forests of Central, East and West Africa, and value chain development for the edible oil from the tree's seeds. This oil has potential in the global food market for production of healthy spreads that are low in trans fats, and the development of a market and supply chain for this product has potential to improve smallholder livelihoods and support global health.

As countries develop, modernization, urbanization, economic development and increased wealth are associated with a nutrition transition – a shift from traditional diets high in cereal and fibre and based on home-cooked basic commodities, to an increased use of packaged and processed food and diets high in sugars, trans fats and animal-source food (Popkin, 2017). This shift towards unhealthy diets, together with reduced physical exercise, is a major contributing factor to the global increase in overweight and obesity and associated NCDs such as cardiovascular disease, stroke, chronic obstructive pulmonary disease, cancer and type 2 diabetes, which are among the top global causes of mortality (WHO, 2018b). Unhealthy diets and malnutrition are among the top ten risk factors contributing to the global burden of disease (FAO and WHO, 2019). Unhealthy diets, particularly energy-dense, nutrient-poor diets with high intake of fats and red meat, are increasingly common among populations in low-income settings with limited health and nutrition literacy (McFarlane *et al*., 2019).

In contrast, traditional healthy whole-food diets based on diverse plant and animal resources gathered from woods and forests, which are mainly low in fat and high in protein and complex carbohydrates, show promise for reducing diseases such as diabetes and obesity (Sarkar, Walker-Swaney and Shetty, 2019, cited in FAO and UNEP, 2020).

FOREST PHARMACEUTICALS

Many commercial pharmaceutical products are derived from tropical forest species (Fabricant and Farnsworth, 2001). Examples include quinine from *Cinchona* spp., previously the most widely used antimalarial; cancer-treating drugs from rosy periwinkle (*Catharanthus roseus*); treatments for enlarged prostate gland from *Prunus africana*; forskolin, which has a variety of medicinal uses, from the root of *Coleus forskohlii*; medicine for treating diabetes from *Dioscorea dumetorum* and *Harungana vismia*; and several medicines based on leaves of the succulents of the Mesembryanthemaceae family. In developed countries such as the United States of America, up to 25 percent of all drugs are plant based, while in fast-developing countries such as China and India, the contribution is as much as 80 percent (McFarlane *et al*., 2019).

Many of these medicines were identified as part of the traditional health systems of forest-dwelling peoples (Chivian and Bernstein, 2008). In 2010, the world market for herbal medicines based on traditional

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Scientists in the United Kingdom using advanced biotechnology to develop improved varieties of *Artemisia annua* with increased artemisinin yields, to help fight malaria while also providing an important source of income for farmers in Asia and Africa

knowledge was estimated at USD 60 billion (Nirmal *et al*., 2013).

Other plant-derived drugs have been discovered through pharmacological screening. An example is paclitaxel (sometimes marketed under the brand name Taxol), a bioactive compound originally derived from the bark of Pacific yew (*Taxus brevifolia*) and considered one of the best anticancer agents developed from natural products (Wheate, 2016).

Some of these products are now synthesized, but others are still collected from the wild. It has been estimated that at least 60 percent of current medicinal plant products are from wild harvesting (Muriuki, 2006). The pharmaceutical use of medicinal and aromatic plants for a wide variety of human ailments has greatly increased globally (Walter, 2001; Rao and Arora, 2004; Ekor, 2014), partly in answer to problems associated with inadequate supply of drugs, prohibitive cost of treatments, side effects of some synthetic drugs and the development of resistance to currently used drugs for infectious diseases. Developing countries provide two-thirds of the plants used in modern systems of medicine (Kumar and Tewari, 2018). However, while global statistics indicate the continued growing economic importance of medicinal plants and plant-based pharmaceuticals, it is primarily developed countries that benefit economically from them. Developing countries export medicinal plant resources to developed countries at cheap rates, but import the pharmaceuticals made from them at prohibitive prices (Bukar, Dayom and Uguru, 2016). An improved ability to harness these resources could have a positive impact on health care delivery in developing countries.

MENTAL, PHYSIOLOGICAL AND SOCIAL HEALTH BENEFITS ASSOCIATED WITH FORESTS

Mental, physical and social well-being are all cornerstones of good health, and their contributions to health are interlinked (Figure 6). An increasing body of evidence demonstrates a positive relationship between exposure to forests and these aspects of human health. The benefits are likely greatest for those living in urban areas and whose basic health needs (e.g. nutrition, housing) are largely met (Tomita *et al*., 2017). Factors such as age, health status, psychological characteristics, fitness, and national and cultural background likely influence the effect of nature exposure (Africa *et al*., 2014).

Mental health benefits

A large share, 14 percent, of the global burden of disease is attributed to mental health disorders, with 75 percent of affected people coming from low-income countries (WHO, 2018b). In developed countries, mental health problems such as depression, anxiety disorders, and alcohol and drug use disorders are common; they affect more than one in six people in Europe each year. Besides the impact on people's well-being, mental illness is estimated to have total costs of more than EUR 600 billion (more than USD 700 billion) across the 28 European Union countries, or more than 4 percent of gross domestic product (OECD and EU, 2018).

Long before the first scientific studies, it was evident that spending time in a nature area away from the everyday urban

environment could facilitate therapeutic processes. In urban settings and developed countries, the evidence of mental health benefits from contact with forests and green areas is now well documented, assessed through such means as measuring stress hormones, evaluating performance on standardized tests (cognitive function) or using self-assessment scales (Tyrväinen, Bauer and O'Brien, 2019). Scientific studies report that forest visits increase positive emotions and decrease subjective stress and negative emotions such as depression, fatigue, general anxiety, uncertainty and tension (e.g. Martens and Bauer, 2013; Tyrväinen *et al*., 2014). Experience in the Republic of Korea suggests that forests can improve psychological stability in patients with depression and alcoholism. After participating in a forest healing programme, patients with depression scored lower on the Beck Depression Inventory (BDI), and individuals with alcohol use disorder scored higher on a self-esteem measure (Shin and

FIGURE 6. Interlinkages among mental, physiological and social health benefits of exposure to nature

Source: Tyrväinen, Bauer and O'Brien, 2019.

Kim, 2007). Many studies show that visits to forests and other natural settings enhance perceived mental state and vitality and support the renewal of directed attention capacity (Tsunetsugu, Lee and Tyrväinen, 2013; Barton and Pretty, 2010). Green spaces and forest environments assist recovery from stress and provide short-term cognitive benefits (Gidlow *et al*., 2016). Conversely, the lack of interaction with nature during early life has been associated with a number of emotional, cognitive and physical difficulties in children (Strife and Downey, 2009; Vanaken and Danckaerts, 2018). Studies in children suggest that outdoor play in nature, which involves interaction with natural features of the environment and "loose parts" (movable, found materials such as sticks and rocks), gives them freedom to develop rich and diverse play experiences and thus promotes healthy mental and social development (Flannigan and Dietze, 2017). A large-scale study of adolescents in the Islamic Republic of Iran found that more time spent in forests and parks improved their self-satisfaction and social contacts (Dadvand *et al*., 2019), especially for boys and older adolescents, those in rural areas and those from lower and higher socio-economic groups.

Several theories have been put forward to explain the positive impact of forests on mental health and well-being. The attention restoration theory, for example, suggests that nature helps to reduce mental fatigue by inspiring unconscious cognitive processes that require little or no effort (Kaplan and Kaplan, 1989). Stress reduction theory suggests that exposure to nature can rapidly evoke positive emotions for those with high levels of stress by triggering a response of the parasympathetic nervous system leading to enhanced well-being (Tyrväinen, Bauer and O'Brien, 2019). A study in the United Kingdom (National Trust, 2019) found that woodland sounds such as birdsong, rustling trees and snapping twigs had a soothing effect on adults, reducing their stress and anxiety. Preliminary analyses of clinical trials with patients undergoing chemotherapy in Brazil (E. Leão, personal communication) suggest that exposure to images of nature (including landscapes, trees, birds and flowers) improves emotional well-being and alertness.

To date, studies of long-term health benefits of frequent contacts with forests have been fewer. Several studies, however, conclude that individuals living in urban areas with more green space have lower stress levels and better well-being than those with less access to green space (White *et al*., 2013; Beyer *et al*., 2014; Pope *et al*., 2015; van den Bosch *et al*., 2015) or less surrounding greenness in general (Triguero-Mas *et al*., 2015). Residential surrounding greenness and the use of green spaces has been linked to a reduced rate of attention deficit hyperactivity disorder (ADHD) in

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Activities in the forest, including shelter building and tai chi, helped to increase the energy, confidence and self-esteem of adult clients of mental health services in Scotland, United Kingdom

children (Amoly *et al*., 2014), and some studies have suggested that natural areas provide a consistent positive environment for children with ADHD (e.g. van den Berg and van den Berg, 2011).

Most of the available studies have been conducted on healthy adults and can therefore only be interpreted in terms of ill-health prevention, while relatively few studies of the curative effect of nature or forest stays on people with confirmed clinical diagnoses have been completed with adequately large data sets (see Tyrväinen, Bauer and O'Brien, 2019). Some studies show, however, that depressive symptoms are alleviated by contact with nature (Bratman *et al*., 2015; Bowler *at al*., 2010; Townsend, 2006). Some studies have also demonstrated the effectiveness of therapeutic programmes in a forest environment in relieving participants' psychosocial stress (e.g. Sonntag-Öström *et al*., 2011). Therapeutic benefits among people with autism have also been demonstrated (Faber Taylor and Kuo, 2006).

Physical and physiological health benefits

An increasing share of the world's population is sedentary, particularly in urban areas. Within urban and peri-urban areas, parks and forested areas designated for outdoor recreation offer opportunities not only for nature experiences, but also for physical activity. Adequate physical activity has been shown to reduce public health costs by reducing the risk for both physical and mental illnesses such as coronary heart disease, type 2 diabetes, certain cancers and depression (Teychenne, Ball and Salmon, 2008; WHO, 2016). At the population level, one possibility for promoting physical activity is to enhance "green exercise", in other words physical activity that takes place in forests and other natural environments. Green exercise provides greater psychological benefits than indoor physical activity and thus greater health benefits in general (Mitchell, 2013; Thompson *et al*., 2011); it appears to foster social cohesion and the restorative or stress reduction qualities of nature (de Vries *et al*., 2013). Good supply and easy accessibility of green areas has been seen to increase the likelihood of frequent exercise (Calogiuri and Chroni, 2014; Pietilä *et al*., 2015).

Nature areas generally provide a safe and attractive setting in which to conduct physical activity (Pyky *et al*., 2018; Mytton *et al*., 2012), although there are differences across countries and regions in how these areas are accessed, perceived and used. The presence of green spaces alone does not necessarily imply their use. Furthermore, not all green spaces are attractive for physical activity, owing to characteristics such as size, available facilities and the quality of the environment. Women may have safety concerns about visiting parks or forest areas alone and may prefer to go only in the company of others (Morris *et al*., 2011).

Larger green spaces with well-maintained paths are likely to be more attractive to adults for outdoor recreation and physical activity than smaller "pocket parks", which may be more attractive for more sedentary forms of recreation (e.g. Giles-Corti *et al*., 2005). A recent study by Pyky *et al*. (2018) in Finland demonstrated that larger, often forested nature areas in suburbs attract residents for green exercise. A short distance to at least a medium-sized, often forested green area and a high personal connectedness to nature ("nature relatedness") were found to be important for green exercise. Studies in Europe and the United States of America (Triguero-Mas *et al*., 2017; Lanki *et al*., 2017; Gidlow *et al*., 2016; Grazuleviciene *et al*., 2015; Sonntag-Öström et al., 2014; Hartig *et al*., 2003) have demonstrated that the physiological effects of visits to green areas depend on the quality of vegetation as well as the size of the area. Although a visit to a small park can promote health and well-being, visits to larger forested areas provide greater environmental qualities such as clean air, tranquillity, biodiversity and space for many visitors.

The physiological benefits of forest visits for city dwellers have been less well demonstrated than the psychological benefits, but studies from China, Japan and the Republic of Korea have shown that a visit to a forest environment lowers blood pressure and pulse rate, reduces cortisol level, suppresses activity of the sympathetic nervous system (which controls the "fight, flight or freeze" response during potential danger) and enhances activity of the parasympathetic nervous system (which inhibits the body from overworking and restores it to a calm and composed state) (e.g. Park *et al*., 2010; Tsunetsugu, Lee and Tyrväinen, 2013). In Japan, visits to the forest have even been shown to improve natural killer cell count, suggesting strengthened human immune function (Horiuchi *et al*., 2013; Li *et al*., 2011) (see also Box 1 on p. 4). This benefit may result from the effect of phytoncides (volatile organic compounds) emitted by trees (Li *et al*., 2009). In Finland, regular visits to the forest have been tested in practice as part of medical treatment for depression and type 2 diabetes (Tyrväinen, Savonen and Simkin, 2017). The forest healing programme in the Republic of Korea (see Box 6 on p. 34) was found to facilitate the recovery of breast cancer patients (Kim *et al*., 2015). Patients with paediatric asthma or atopic dermatitis also obtained relief from their symptoms after undergoing a forest healing programme (Seo *et al.,* 2015). Most of the comparisons in Asia have been made between large recreation forests in peri-urban areas and densely built-up urban environments. The heterogeneity of study designs and results makes it difficult to draw solid meta-level conclusions from physiological studies, but most of them show that forest visits contribute to stress reduction and relaxation, which also result in changes in human physiology (Bowler *et al*., 2010; Tyrväinen, Bauer and O'Brien, 2019).

From the associations between mental state and cardiovascular physiology, it can be suggested that even short visits to green environments may lead to positive changes in cardiovascular risk factors as a result of stress recovery. More research is needed, however, to study the dose–response relationship, individual differences and long-term health effects, the role of forest type and size, as well as possible forest effects in rehabilitation and recovery from illnesses (Tyrväinen, Bauer and O'Brien, 2019). Positive effects may not be experienced equally by different groups of people (e.g. in terms of age, cultural background or disease).

Some countries, such as Germany, have a long tradition of using forests as sites for physical healing and recovery (Box 4). More recently, scientific studies and field experiments conducted across Japan have demonstrated and verified the benefits of *shinrin-yoku* or "forest bathing", as the practice of peaceful walks in forests is called there (Park *et al*., 2010). Japan is a highly urbanized but also highly forested country (with forests covering 68.4 percent of the land area [FAO, 2020a]), and its population has traditionally used forests for common recreational activities such as walking and mushroom picking. Breathing in fresh air and substances emitted from trees, as well as exercise in forest environments, is believed to promote both physical and mental health. Since the 1980s, a network of forest therapy centres has been created to provide urban people with access to forests, health guidance and the opportunity to use forests for health promotion (Box 5). The practice of forest bathing for well-being is now gaining popularity in Asia, some European countries and the United States of America. Tourism that includes forest bathing in the itinerary is also being promoted in Brazil (Freeway viagens, 2020).

Similarly, outdoor recreation and forest visits are a common leisure activity in northern Europe. National outdoor recreation surveys in Finland, Norway and Sweden show high participation rates, with 76 to 91 percent of the adult population paying visits to forests each year (Edwards

et al., 2013). An average person in Finland visits a forest 120 times per year (Sievänen and Neuvonen, 2010). Traditional forest-based leisure activities such as gathering mushrooms and berries and game hunting keep people physically active in a natural way. The human health benefits are acknowledged in national forest policies, in the management of State-owned and many municipal forests, and increasingly in public health promotion (Jäppinen *et al*., 2014).

Box 4 Use of forests for human health in Germany

The German people have long appreciated the role of forests in disease prevention and in enhancing health and the quality of life. For hundreds of years forests have been used as sites for sanatoria for curing tuberculosis and other diseases and as places for exercise. Many spas and long-term nursing facilities are situated in forests, and some German states promote the health benefits of forests by allowing health insurance to cover the use of forests for health purposes and by certifying certain forests areas and facilities for their contributions to human health. Since 2019, for example, the state of Mecklenburg–Pomerania has allowed spas and municipalities to apply for legal designation of particular forest areas as recreational, curative or healing forest, based on specific criteria such as quiet setting, air quality, trail network and signage, infrastructure, therapy provision and staff (Kotte, 2019).

Long-established forest-based therapies include *Klimatherapie*, the use of changing climatic elements in the forest to heal disease, and *Terrainkur*, a method of exercise that utilizes the ups and downs of forest walking trails. Garmisch-Partenkirchen in southern Germany is a particularly popular area for these types of forest therapy.

Kneipp therapy, developed more than a century ago by the priest Sebastian Kneipp (1821–1897), is a holistic natural treatment system based on exercise, hydrotherapy (for which streams in nature are ideal) and nutritional balance. Currently, 64 nursing homes in German forests offer Kneipp therapy. Germany's social health insurance covers three weeks of Kneipp therapy every four years under a doctor's prescription. Kneipp therapy is a very popular means of promoting health; millions of people visit the villages where it is offered.

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People in domiciliary care using forest for therapeutic purposes

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Accommodation facility in forest for domiciliary care

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Kneipp therapy facility

Box 5 Forest therapy in Japan

Since the Head of the Japanese Forestry Agency, Tomohide Akiyama, coined the term "forest bathing" in 1982, the practice of promoting human health in forests has steadily increased in Japan. Since 2004, a nationwide research project on the therapeutic effects of forests has investigated the physiological effects of the total forest environment and its individual elements, such as the odour of wood, the sound of running streams and forest scenery. These experiments have demonstrated improvements in blood pressure, heart rate, stress hormone levels and autonomic nervous activity (Tsunetsugu, Park and Miyazaki, 2010).

In 2006, the Forest Therapy Society initiated a certification programme to register forest therapy bases (FTBs) and forest therapy roads (FTRs) as scientifically approved locations in forests and urban environments designated for promoting a healthy lifestyle and encouraging relaxation. Forest therapy bases are forest areas designated for promoting a healthy lifestyle and encouraging relaxation, where a variety of forest therapy programmes are provided aimed at improving health or stabilizing the mind and body. Forest therapy roads are walking paths, wider than a regular sidewalk, providing gentle slopes and a leisurely environment for a 20-minute walk.

Certification of FTBs and FTRs consists of physiological and psychological testing to check the health promotion effects, developed through years of research; the natural and social conditions; and the facility operational plan. After certification is granted, quality is maintained through a periodic review process. To date, 64 FTBs and FTRs have been registered and are operating across Japan. Each FTB and FTR provides training and certification for guides who deliver the forest therapy programmes. The programmes are unique rather than standardized and typically link walking and other activities with the local cultural and natural resources.

Forest therapy in Japan is well supported at the national and local levels. For example, the central government research institute provides research support for the certification programme, and local governments market and promote FTBs and FTRs. Local residents benefit by providing forest healing programmes, food and accommodation for users.

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Local healthy food is one of the forest therapies

©Pyoung Sik Yeon

A forest therapy trainer provides instruction in walking correctly at a forest therapy base

Spiritual benefits

Reconnecting to nature can be a means of meeting spiritual needs. In developed countries, national parks and similar protected areas offer some of the best opportunities for experiencing the solitude, beauty, silence, grandeur and harmony of nature. Recent surveys conducted in some countries (e.g. Finland and the United Kingdom) show that enjoying such a spiritual experience is one of the main reasons visitors go to protected areas (Mallarach, 2012). Many protected areas in Europe include landscapes sacred to ancient civilizations or local traditional religions or have been established over ancient routes of pilgrimage. These protected areas foster landscape connectivity as well as the restoration of natural and cultural heritage. Parks and protected areas often develop creative and effective approaches to allow different societal groups, mostly urban, to enjoy a profound reconnection with nature – for example, through the documentation and mapping of local myths and legends and the origin of local place names.

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The Forestry Commission in the United Kingdom consults with representatives of disabled access groups to ensure equal access and enjoyment of the outdoors for all people

RECOMMENDATIONS: HOW TO TAKE ADVANTAGE OF FORESTS TO PROMOTE HEALTH AND NUTRITION IN URBAN SOCIETIES

In principle, long-term mental and physical health benefits of forests are gained through repeated use. Regional and national forestry and health policies should address the potential role of forests in health and nutrition promotion and ill-health prevention, focusing especially on forests and woodlands in and around towns and cities. In this process, greater collaboration should be promoted among forestry, conservation, land-use and urban planning experts, as well as public health officials and others responsible for supporting healthy living (e.g. Marušáková and Sallmannshofer, 2019). Land-use planning should target an adequate supply of forests for recreation in urban and rural areas.

Many highly urbanized countries have undertaken programmes and interventions to promote forests as "a great health machine" (Kaplan, 1993) and to encourage populations to use them for their well-being. In the Republic of Korea, for example – where forests account for 64 percent of the total land area and 81.3 percent of the population visits a forest more than once a year – widespread media coverage has substantially raised awareness of the therapeutic functions of forests. Both the private and public sectors provide forest healing services to meet the rising public demand, including the use of forest facilities by medical groups. Building on the country's successful reforestation initiatives of the past decades, the Korea Forest Service (KFS) has formalized the concept of forest for human well-being and launched a forest healing programme using specific therapy centres (Box 6). Next steps could include additional policies to diversify and vitalize private forest-related markets, to support private businesses and to create jobs in relation to forest welfare. This approach requires close collaboration among ministries or government departments that are concerned with public welfare, such as the Ministry of Health and Welfare, the Ministry of Education and the Forest Service.

Other countries with well-developed forest therapy initiatives include Japan

Box 6 Forest policy and forest healing in the Republic of Korea

As the population of the Republic of Korea ages, the government expects that medical expenses will increase continuously. With rigorous evidence from continuing research showing the therapeutic effects of forests in boosting the immune system, facilitating recovery from cancer and providing relief from paediatric asthma, atopic dermatitis, stress, depression, anger, fatigue, anxiety and confusion (see p. 30), the Korea Forest Service (KFS) has been promoting a policy of "From cradle to grave: Life with forests" to encourage the use of forests for enhancing people's well-being and quality of life in different ways, customized by life stage. Examples include prenatal classes, forest kindergartens, camping and healing forests, and forest burial (Williams, 2017).

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Medical check-up at Saneum Therapeutic Forest

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Visitors from a company enjoying a winter exercise programme

KFS has enshrined the concept of forest for human welfare in law. The Forest Welfare Promotion Act of March 2015 provides an institutional basis for promoting comprehensive forest welfare services, including cultural, recreational, educational and therapeutic services (see Box 13 in Chapter 6).

Through the Forest for Health programme, KFS has established 29 healing forests – with amenities such as hiking trails, resting chairs, foot massage and foot baths – and is currently developing 38 more. It has launched a system for training more than 500 forest healing instructors to develop and manage forest healing programmes and to provide specialized healing services to the public.

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People walking on a wheelchair-accessible deck trail at one of the national forest therapy centres

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People (mostly cancer patients) taking rest at Jangsung Therapeutic Forest

(described in Box 5), Denmark (Box 7) and Finland (Box 8).

New Zealand has pioneered "green prescriptions", recommendations for physical activity and diet that recognize the added benefits of exercising in nature as part of a holistic approach to addressing NCDs, mental health issues and social isolation (Robinson and Breed, 2019). Nature prescription is also being tried in Scotland. In Germany, as described in Box 4, public health insurance covers the use of forest for health purposes.

Box 7 The therapy forest and forest garden in Denmark

In an existing arboretum near Copenhagen, the therapy forest garden Nacadia offers nature-based treatment to people suffering from stress-related diseases, and the health forest Octovia offers nature experiences for promoting good health and preventing ill health (Stigsdotter, 2015). Both areas have been designed according to an evidence-based health design process and the concepts of landscape architecture. Similar concepts have been used in designing therapy gardens in Sweden (Grahn *et al.*, 2010).

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Octovia health forest, Denmark

Nacadia covers an area of 1.1 ha on slightly sloping terrain and is a nature-like setting with a forest-like appearance. Approximately two-thirds of the area is under closed tree canopy, while the remaining one-third is open. The therapeutic approach used on-site is mindfulness-based cognitive therapy, in which components of nature are used as therapeutic tools. The therapy programme, led by two psychologists and a gardener, is divided into four components: individual therapeutic sessions, mindfulness exercises, garden activities and participants' own time. The garden also serves as a research laboratory for studying the effects of health design and nature-based therapy, and as an education, knowledge and demonstration centre.

Octovia covers approximately 2 ha. It is open to the public and is a popular recreation area. In the design of the health forest, eight spatial settings have been demarcated, referred to as "rooms", each embodying one of eight "perceived sensory dimensions": social, prospect, rich in species, serene, culture, space, nature and refuge (Figure 7). A 750 m trail connects the eight rooms in a circular walk. Octovia is envisioned as a hub for researchers, practitioners, students and others who are interested in nature, health and design. A research study is currently investigating which of the eight rooms are experienced as the most restorative and why. Half of the informants start in the health forest and a few days later visit an urban environment, while the rest of the informants do the opposite. Their physiological data (heart rate variability, pulse and blood pressure) are also collected.

▶▶

FIGURE 7. Eight perceived sensory dimensions used in designing health forests in Denmark and Sweden

Perceived sensory dimension	Key nature qualities and features
SOCIAL	Possible to view entertainment or exhibitions Availability of open-air restaurant(s)
PROSPECT	Vistas over the surroundings Well-cut lawns
RICH IN SPECIES	Several animals (birds, insects, etc.) Natural plant and animal populations Many native plants to study
SERENE	Silent and calm No bicycles Possible to avoid contact with many people
CULTURE	Decorated with fountains, statues Wide range of introduced, ornamental and aromatic plants
SPACE	Spacious and free Areas not crossed by roads and paths Lots of trees
NATURE	Nature-like Wild and untouched Freely growing lawns
REFUGE	Many bushes Kept animals that children and adults may feed and pet Sandpits

Source: Adapted from Stigsdotter, 2015.

Box 8 Promoting public health with forests in Finland

Although the life expectancy of Finnish men and women is relatively high compared with the international average, at the population level the country faces several large-scale health challenges, including not only traditional cardiovascular risk factors (a sedentary lifestyle, obesity and smoking) but also a growing number of mental and physical problems related to involuntary aloneness and anxiety.

With 73.7 percent forest cover (FAO, 2020a), Finland is one of the world's most forested countries and the most forested country in Europe. The forests have traditionally provided the population with wood, berries, mushrooms, wild herbs and recreation. The "everyman's right" (despite the currently perceived gender bias of its name) allows all citizens free access to all undeveloped land in Finland. However, most of the health benefits of forests today are sought in urban and peri-urban forests, because of their easy accessibility.

Evidence from 20 years of national research on the benefits of relaxation and exercise in nature has resulted in a number of practical initiatives, including the following:

- The first "forest well-being trail" was opened at Ikaalinen Spa in western Finland in 2010. Signposts along the trail suggest mental exercises to help visitors deepen their experience of nature, focus their feelings and become calmer.
- "Moved by Nature", a large collaborative project in eastern Finland (2013–2015) (ten Brink *et al.*, 2016), aimed at increasing the use of forests for recreation and physical activities by different population groups, such as new immigrants, youth with increased risk of social exclusion, unemployed people and people at high risk of type 2 diabetes.
- The health care centres in Sipoo and Porvoo municipalities in southern Finland integrate regular visits to nature in treatments for type 2 diabetes and depression.
- Virtual forest environments and nature experiences are being created in indoor work, educational and health care environments to make nature available to those who do not have easy access to it (Ojala *et al*., 2019).
- *Meijän polku* ("Our path") is a large cross-sectoral collaborative programme in central Finland, initiated in 2017, to encourage people to improve their health through the use of forests, including urban forests, national parks and other large dedicated outdoor recreation areas (Meijän polku, 2020). This holistic approach to public health focuses on increased physical activity, adequate rest, contact with nature and community well-being. It aims at gradual but long-lasting behavioural change. The programme is based on the voluntary involvement of professionals from health care, physical education, education and the State forest agency Metsähallitus Parks and Wildlife. The operational goals vary for different population segments (active/sedentary, young/old, healthy/chronically ill). Services, activities and tools are available free of charge for individuals and groups, tailored to all seasons and weather conditions.

Box 9 **Healthy Parks Healthy People**

In recent years, many protected area management agencies have put efforts into promoting and enhancing public health with forests and other types of nature area. Healthy Parks Healthy People, launched by Parks Victoria in Australia in 2010, is a global movement that harnesses the power of parks and public lands as a health resource, based on the concept that all parks – urban and wildland – can considerably support people's physical, mental and spiritual health, their social well-being and the sustainability of the planet. Other countries that have developed national Healthy Parks Healthy People programmes include Canada, Finland and the United States of America.

In the United States of America, for example, the National Park Service has set in motion a five-year Healthy Parks Healthy People Strategic Plan (2018–2023) aiming to bring about lasting improvements in citizens' lifestyle choices and their relationship with nature and the outdoors. The strategy specifies mutually supportive goals for healthy parks – such as improvement and maintenance of facilities, programmes and environments – and goals for healthy people, including community engagement and partnerships to amplify the health benefits of parks, activities to enhance the economic well-being and resilience of local and regional communities, and the role of National Parks System employees as ambassadors for healthy living. Although the programme's core activities are within the National Park Service, the programme also works with state and local parks as well as business innovators, health care leaders, scientists, foundations and advocacy organizations to advance the role of parks in the health of society.

"Forest schooling" uses woods and forests as a means of developing physical, social, cognitive and life skills and building independence and self-esteem in children and young adults (O'Brien, 2009). This concept has long been popular in Scandinavian countries and is now being adopted elsewhere. Children enrolled in forest schools are less likely to suffer from overweight or obesity, ADHD and common infections (Blackwell, 2015; Isted, 2013). The Criança e Natureza (Child and Nature) programme in Brazil develops projects to create favourable conditions for urban children to grow and develop in direct contact with natural environments (Instituto Alana, 2020).

Internationally, the Healthy Parks Healthy People movement (Box 9) promotes the benefits of national parks and other conservation areas to increase human well-being and reduce NCDs (Maller *et al*., 2008). This movement has also pioneered some significant cross-sectoral relationships between government health and environment sectors. In Finland, for example, the health benefits of forests are acknowledged in national forest policies and in managing State-owned and many municipal forests.

As public parks and recreation areas are often the only areas available to urban residents for outdoor exercise, they should be given appropriate attention in urban planning and land-use decisions (e.g Tyrväinen *et al.*, 2005). Derks, Giessen and Winkel (2020) noted an increase in recreation in urban and peri-urban forests as a result of lockdown imposed during the 2020 COVID-19 pandemic, as well as an

influx of first-time visitors. These changes pose challenges for forest managers and urban forest policy, including threats to forest biodiversity due to high visitor numbers, but also provide a unique opportunity to highlight the importance of urban and peri-urban forests as a critical infrastructure for citizens' well-being.

Promotion of healthy diets with forest foods

The concept of forest therapy is partly about inspiring healthy choices in a broader sense. To draw the greatest benefit from healing forests, outdoor exercise and relaxation in nature are complemented by healthy eating. Hotels and restaurants associated with forest healing centres contribute by serving meals that use fresh, nutritious and locally sourced foods, such as roots, shoots and vegetables. The sale of local forest food products (e.g. nuts, dried mushrooms) to visitors can also provide a source of income for local forest communities. Such foods are also becoming popular in urban areas. For instance, several restaurants in Seoul, Republic of Korea, promote healthy cuisine that includes wild plants from mountain forests, which is inspired by Buddhist traditions.

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Healthy forest food, typical of a mountain village, served at a restaurant in Seoul, Republic of Korea

The commercialization of novel forest foods brings about a need for appropriate legislation and food safety standards. The increasing acceptance of insects in some countries where they were not previously consumed, for example, has resulted in initiatives to farm them for this purpose. The European Union's Novel Food Regulation (EU, 2015), which came into force in January 2018, recognizes the legitimacy of whole insects and their parts as novel foods, facilitating the marketing of insect-based foods.

4. HEALTH CONSEQUENCES WHEN FORESTS AND TRADITIONAL FOREST COMMUNITIES BECOME ALTERED

As discussed in the preceding chapters, forests generally play a very different role in the health of people in different contexts: rural or urban, socio-economically developing or highly developed. With increasing globalization, urbanization and land-use change, however, these distinctions are becoming blurred. Forest boundaries are increasingly fragmented, and traditional forest communities are becoming less remote from urban areas. These changes also have a role in human health, from changes in the diet and activity levels of forest dwellers and erosion of traditional health-related knowledge, to issues associated with vulnerability to transmissible diseases and the rise of novel zoonotic diseases – those crossing from animals into humans. Environmental changes, including alteration of forests, wildlife population structure and biodiversity, may modify the abundance or dispersal of particular hosts, vectors, and/or pathogens. Altered hydrological functions may favour water-borne pathogens (Wilcox and Ellis, 2006). Climate change, including alteration in temperatures, precipitation and seasonality, also affects the survival and range of disease hosts, vectors and pathogens, and indeed of forest biodiversity in general.

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Increased connection with the world beyond the forest can have an influence on local health, diet and related traditional knowledge (Cuyabeno, Ecuador)

HEALTH ISSUES ASSOCIATED WITH A CHANGING WAY OF LIFE FOR FOREST DWELLERS

Many local and Indigenous communities have based their livelihood, culture and identity on forest ecosystems over many generations. They have often traditionally had a nomadic or semi-nomadic way of life that depends on the non-intensive use of extensive areas of forest.

As these groups settle in permanent villages, their increasingly sedentary lifestyle generally compromises their health and well-being (Dounias and Froment, 2006). Depression, social exclusion, and rapid and often unexpected environmental changes, as well as greater contact with broader societal trends, may contribute to unhealthy behaviours such as tobacco and alcohol abuse. Poor sanitation results in more frequent contact with human and animal wastes, thus encouraging faecal pollution and increasing parasitic

load. Rates of intestinal worms – which cause anaemia and possibly delayed growth of children – have generally risen with a sedentary way of life. Faecal pollution is also a source of bacterial and viral infections of the gut, which are major causes of malnutrition, infectious diarrhoea and child mortality.

Industrialization and urbanization, which generally follow economic growth in tropical forests, bring with them changes in a population's diet and nutritional status. The shift to a sedentary way of life affects food availability, food distribution and dietary diversity, and particularly influences children's nutritional status and health. Dounias and Froment (2006) observed that certain resettled nomadic groups in Cameroon and Indonesia tended towards an excess intake of energy-dense foods rich in fat and free sugars but low in complex carbohydrates, a diet linked to risks of degenerative chronic diseases of middle and later adult life, particularly cardiovascular diseases and certain types of cancer. As a result of their decreased dietary diversity and physical activity, these former hunter-gatherers had begun to exhibit other nutritional disorders such as anaemia, obesity, hypertension, elevated cholesterol levels and diabetes. The good fitness for which they had been renowned became compromised, dropping below that of their farming neighbours.

Dietary transition

Remote forest-dwelling communities can have healthy, diverse diets based on local biodiversity (albeit with some periods of poor food availability), but as their contact with the outside world increases, the quality of the diet can quickly collapse towards a lack of diversity and high energy density with low nutritional value – the nutrition transition described in Chapter 3 – raising health problems associated with a high trans fat, nutrient-poor diet, including obesity and NCDs. Decreased access to land and deforestation have both had a large role in downscaling traditional food production systems, thus lessening dietary diversity and increasing dependence on purchased (often less nutritious) foods (Galway, Acharya and Jones, 2018). In addition, the globalization of culture and commerce fosters a westernization of developing-country food systems and diets. Where high rates of infectious illness persist and undernutrition and overnutrition coexist, communicable and non-communicable diseases create a double burden (Johns and Maund, 2006).

Demand for red meat, historically popular in Western countries, is growing in developing economies, in part because of its perceived status (McFarlane *et al*., 2019). Excessive beef consumption not only has profoundly adverse health consequences (Kmietowicz, 2017), but also is deeply problematic for sustainable development (Potter, 2017), as beef production is a major driver of deforestation and desertification (Armenteras *et al*., 2017). Increased cattle numbers contribute to rising quantities of methane and nitrous oxide, driving climate change. Awareness of these detriments has not yet driven per capita reduction of meat production or consumption in traditional (developed) producing countries.

Changes in developing-country food systems affect both human health and the health of ecosystems (Johns and Maund, 2006). The loss of access to important natural resources because of environmental degradation, economic changes (including changes in land use), cultural erosion or poverty can result in food insecurity, malnutrition and disease for rural people.

Urbanization is taking place considerably faster in developing regions than in developed regions; in 2018, 3.2 billion people lived in cities in developing regions, compared with 1 billion in developed regions. Urbanization, combined with overall population growth, could add another 2.5 billion people to urban areas by 2050, with close to 90 percent of this increase expected to take place in Asia and

Africa (UN, 2019). This rapid urbanization, together with the commercialization of the food supply and other subsistence items, results in considerable changes in patterns of consumption and resource use, including a tremendous increase in the number of humans who depend on foods that are purchased and produced by others outside cities. When rural people move to cities, they may no longer have access to nutritious products of local biodiversity because these are either unavailable or unaffordable. With population growth, human diets become increasingly dependent on intensified production systems of cereals, sugar, oilseeds, other staple crops and animal-source foods. Three crops alone – rice, wheat and maize – are the world's most widely cultivated crops and, taken together, are the single most important item in the human diet, accounting for an estimated 42.5 percent of the world's food calorie supply and an annual harvest of some 2.5 billion tonnes (FAO, 2016). These staples are important commodities in global trade and together form the bulk of the diet of urban dwellers in Africa, Latin America and Asia. The food supply of urban dwellers in many developing countries increasingly depends on food imports, while local producers, particularly small-scale farmers, have difficulty competing (Johns and Maund, 2006).

While the availability of affordable energy-rich but nutrient-poor food contributes to food security and has reduced the number of hungry people, the food choices of poor people are limited. Lack of infrastructure and support for small-scale production may keep local forest products unavailable or expensive in local markets. As supermarkets take a larger market share in developing countries, local producers have fewer opportunities to sell their diverse products, particularly wild foods from forests, with the possible exception of those that can market to speciality niches (Johns and Maund, 2006).

EROSION OF TRADITIONAL KNOWLEDGE

Rapid industrialization, major socio-economic and cultural trends affecting contemporary Indigenous societies, and decline of the world's biological, linguistic and cultural diversity, together with ecosystem degradation and deforestation, are leading to a disappearance of traditional knowledge of edible and medicinal forest plants and their associated benefits (FAO and UNEP, 2020; Reyes-Garcia *et al.,* 2013). These changes have negative consequences for food security, nutrition and disease prevention.

Preserving and maintaining traditional knowledge associated with forest biodiversity, and protecting the rights of rural people to share the benefits from the use of their knowledge and resources, as recognized in the Nagoya Protocol (CBD, 2011), is extremely important for the health and well-being of local communities as well as for the global community (FAO and UNEP, 2020).

TRANSMISSIBLE DISEASES

As nomadic societies settle and settlements near forests become larger and more densely concentrated, exposure to transmissible diseases (e.g. smallpox,

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Increased settlement in remote forest areas, or alteration of forest structure and biodiversity, may influence the transmission of infectious diseases (natural forest, Democratic Republic of the Congo)

measles, mumps, cholera, rubella, diphtheria, influenza) increases. In a small, isolated group of people, these pathogens cannot last for long: they race through the group and every person is infected; subjects either perish or develop an enduring immunity, and the pathogen dies out once there is no one left to infect. But wherever humans gather to form a large, concentrated population, infectious diseases have a sufficient critical mass of inhabitants to permit propagation (Dounias and Froment, 2006).

Low population density and a nomadic way of life effectively protected against vector-borne diseases such as malaria, as human potential hosts were diluted in the environment and thus less visible to vectors. Landscape alterations and developments that accompany the settlement of nomadic societies, such as the building of roads, timber extraction, mining and agro-industrial plantations, lead to outbreaks of malaria. Temporary workers in areas of high and endemic malaria (e.g. logging camps, agro-industrial villages) sometimes bring back acute forms of disease-causing parasites to their villages, which may set off an epidemic. In 2002, this happened in two remote forest villages in East Kalimantan, Indonesia, when workers returning from Malaysia brought back a severe form of malaria which killed 28 children (half the population under five years of age) within just a few months (Dounias and Froment, 2006).

In 2017, malaria was estimated to affect 219 million people, with almost half a million deaths, 90 percent in sub-Saharan Africa (WHO, 2018c). Forest management may have a local impact on the risk of malaria and some other diseases originating in or associated with forests (McFarlane *et al.*, 2019). For example, rutted ground, cleared patches and roads resulting from forest clearance provide opportunities for free-standing water at an optimum temperature for mosquito development (Guerra, Snow and Hay, 2006). The relationship between malaria transmission, forest cover and deforestation is complex and appears to vary regionally. Deforestation appears to increase malaria risk in Africa and the Americas and to diminish it in Southeast Asia.

Evidence about the effects of forest biodiversity loss on the transmission of infectious diseases is somewhat contradictory (Aerts, Honnay and Van Nieuwenhuyse, 2018; Tyrväinen, Bauer and O'Brien, 2019). Areas of naturally high biodiversity may have increased abundance of vectors and serve as a source pool for new pathogens. However, mounting evidence suggests that biodiversity loss frequently increases disease transmission. One possible explanation is that in a more biodiverse community, a pathogen may be more likely to encounter unsuitable hosts; thus loss of biodiversity may actually increase encounter rates between pathogens and suitable hosts (Keesing *et al.*, 2010). Preserving intact ecosystems and their endemic biodiversity should generally reduce the prevalence of infectious diseases. A study of 700 municipalities in the Brazilian Amazon found that malaria, acute respiratory infection and diarrhoea incidence were significantly and negatively correlated with the area under strict environmental protection (Bauch *et al.*, 2015).

EMERGING ZOONOSES

Global changes, including land-use change, encroachment of humans into forests and other wild landscapes, deforestation and habitat erosion, and globalization of wildlife trade with inadequate regulation, have increased the opportunities for pathogens to jump from wild and domestic animals to people.

Around 60 percent of all infectious diseases in humans, and 75 percent of all emerging infectious diseases, are zoonotic, in other words they originate in animals (UNEP, 2016). COVID-19 is a timely example. In many cases, the emergence of zoonotics may be linked to increased human contact with wildlife as a result of forest area change and the expansion of

Box 10 Habitat fragmentation and increased human–wildlife contact

Human activities have converted nearly 50 percent of the world's terrestrial landmass from natural habitats into agricultural land (crops and grazing lands for domestic animals), with some of the highest rates of agricultural conversion taking place in tropical forests over recent decades. Agricultural expansion accounts for an estimated 75 percent of recent forest loss in Africa, of which more than half is related to subsistence.

Habitat fragmentation, or a change in the configuration of remaining habitat, results in the presence of small patches of forest ("core") which are embedded in farmland, pastureland or human settlements. In African landscapes with diverse wildlife populations, it is at the edges of these patches – the boundaries between two habitat types – that physical encounters between non-human primates and humans occur, and the risk of harm, infection transmission and local biodiversity loss is increased. Structurally, fragmented landscapes have a greater edge length per core forest area (referred to as "edge density").

Core loss and habitat fragmentation are dynamic processes that affect species' population sizes, densities and the probability of interspecies contacts at different points during a landscape transition. Edge length and human use of wild animal habitat has been positively correlated with interspecies contact rates and increased pathogen sharing.

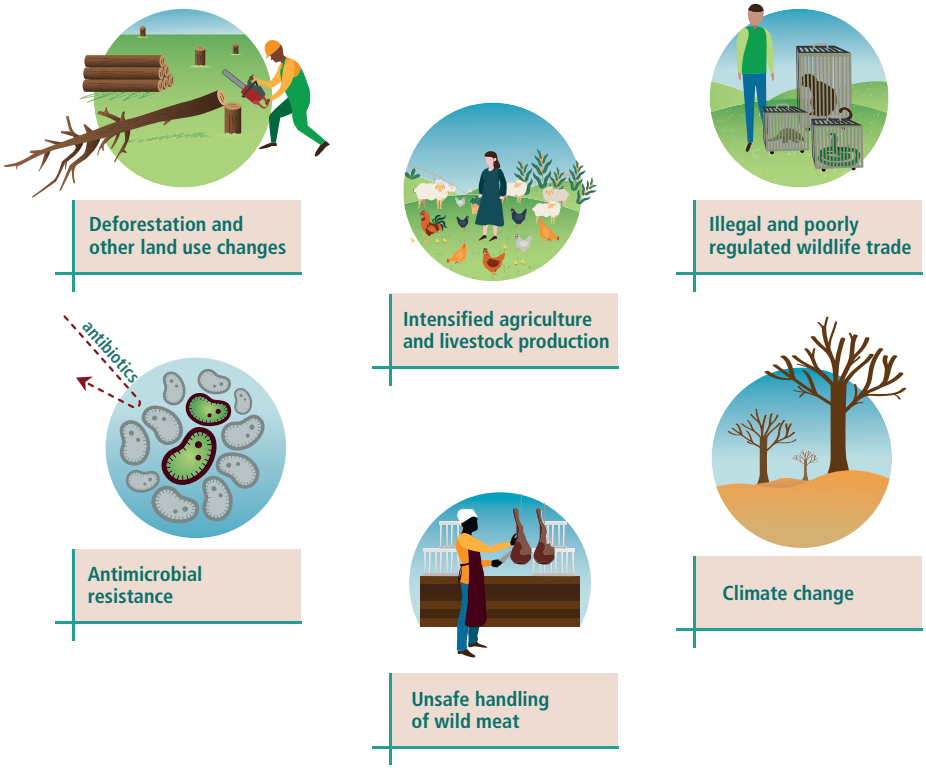
A recent study combining behavioural survey data collected from small-scale agriculturists living near forest fragments around Kibale National Park in western Uganda with high-resolution satellite imagery provides empirical evidence that forest landscape fragmentation and increased edge density around households, combined with certain activities of smallholders in forest patches – such as collection of small trees for construction, and foraging and hunting for food in forested habitat – significantly increase the likelihood of direct human contact with non-human primates, making transmission of zoonotic disease more likely. The study points to the importance of collecting spatially explicit data on land use and human behaviour to improve prediction of the likelihood of physical interactions between humans and wildlife and assessment of the risk of zoonotic emergence in rapidly changing landscapes around the globe.

Source: Bloomfield, McIntosh and Lambin, 2020.

human populations into forest areas (Wilcox and Ellis, 2006) (see Box 10 and Figure 8). HIV and Ebola are both zoonotic diseases with clear forest origins. A remote-sensing-based study in Central and West Africa showed a significant association between Ebola outbreaks and recent forest losses (within the previous two years), suggesting that preventing the loss of forests could reduce the likelihood of future outbreaks (Olivero *et al.*, 2017). Extractive industries, deforestation, habitat degradation and increasing encroachment of people into forest lands are increasing risks of novel forest pathogens affecting people. Bat-associated viruses, for example, have emerged as a result of loss of bat habitat through deforestation and agricultural expansion (UNEP, 2016).

The emergence of novel zoonotic diseases becomes more acute with settlement (Dounias and Froment, 2006). The risk of contracting zoonotic diseases is elevated in human-inhabited or domesticated forest by the proliferation of rodent-borne disease vectors, as rodents are attracted by domestic garbage and food storage. Frequent contact with a broader range of domesticated animals also raises opportunities for pathogen transfer between species.

FIGURE 8. Factors in emergence of zoonotics



Source: Adapted from UNEP, 2020.

It is probable that new zoonoses have historically emerged from wildlife many times but failed to spread from the focus of emergence because infected victims living in scattered small hamlets either died or recovered before coming into contact with larger human populations (Dounias and Froment, 2006). In modern times, the exponential rise in volume and speed of trade and travel has transformed the epidemiology of emerging infectious diseases, giving them global rather than local importance – as the current outbreak of COVID-19 dramatically illustrates.

Former hunter-gatherers who now live in permanent villages but continue to depend on bushmeat, for their own diet and for trade, are more likely to contribute to the diffusion of zoonotic diseases. They have higher levels of immunoglobulins in their blood than do agriculturists, which indicates a higher propensity for infection. Infection often leads to malnutrition, which in turn leads to low resistance and thus to further infection, in a vicious circle (Dounias and Froment, 2006).

CLIMATE CHANGE EFFECTS ON THE FOREST–HEALTH NEXUS

Human-induced climate change is a major factor for disease emergence. It influences the environmental conditions that can affect the survival, reproduction, abundance and distribution of pathogens,

vectors and hosts, as well as the means of disease transmission and the outbreak frequency. Growing evidence suggests that disease outbreaks or epidemics may become more frequent as climate continues to change (UNEP, 2016).

Human health issues are also arising as irritant or allergy-producing forest species migrate into new habitats or regions. In Europe, for example, the range of the oak processionary moth, *Thaumetopoea processionea*, is expanding northward (FAO, 2008). The caterpillars of this species are covered with bristles that carry a skin-irritant toxin and can cause respiratory problems if inhaled, so its altered range is causing new public health problems. Changes in species distributions may also enhance pollen production (Tomalak *et al*., 2011). In Europe and North America, giant hogweed (*Heracleum mantegazzianum*), whose phototoxic sap causes blisters and scars in humans, may also be spreading with climate change, while ragweed (*Ambrosia artemisiifolia*), a common cause of allergies in these regions, is experiencing longer growing seasons (Lake *et al*., 2017; Climate Central, 2019).

The increasingly frequent forest fires seen with global climate change also have impact on human health, beyond their threat to lives and property, as they are sources of major air pollutants. More generally, by affecting the survival and range of forests and forest biodiversity, climate change can influence the contributions of forest resources to human livelihoods, food security and nutrition and, indirectly, any of their contributions to human health.

Yet forests can also help to mitigate some of the human health related effects of climate change, for example by mitigating heat and mediating water flows and flooding from increasingly intense storms – of particular importance in developing countries, which are suffering the greatest impacts of climatic change and environmental degradation. Shade provided by urban forests and trees can reduce the urban heat island effect by 4 to 5 °C in some settings (Tyrväinen *et al*., 2005; Livesley, McPherson and Calfapietra, 2016).

5. POLICIES AND GOOD PRACTICES AT THE FOREST, HEALTH AND NUTRITION NEXUS

ONE HEALTH

In view of the inextricable connection of human, animal and environmental health, the best way to promote health and well-being is to prevent and mitigate risk at the interface between humans, animals and their various environments through an integrated "One Health" approach (Figure 9). This approach involves bringing together professionals and policy-makers in forestry, natural resources, agriculture, livestock, and public health and nutrition, to ensure balance among all the relevant sectors and disciplines. By incorporating One Health programming in national policy, legislation and budget planning, countries can mandate cross-sectoral collaboration, requiring, for example, health ministries to consider forest resource issues and forestry ministries to consider health and nutrition issues in their programming.

The aim of achieving optimal health outcomes for human communities should be taken into account in forest management and planning, not only for rural areas but also for peri-urban and urban areas, in both developed and developing countries. These considerations are especially vital in light of continuing natural resource degradation and expected increases in the severity of forest risks such as wildfires, storms and vector-borne diseases, which have considerable ramifications for public health. Land-use planning for urban or agricultural expansion should take into account the importance of buffers that would mitigate potential impacts associated with higher contact rates among wildlife, livestock and people. In addition, prevention of various forms of malnutrition and disease, including diet-related NCDs, needs to form an integral part of resilience building, especially among the most vulnerable segments of the population.

The development of successful programmes and interventions depends not only on cross-sectoral cooperation but also on encouragement of public participation and inclusivity. To that end, forest tenure issues need to be addressed to provide the necessary incentives to manage forest resources sustainably. Interaction with all stakeholders and local communities is essential. Communication and public awareness campaigns are needed to support multipurpose forest management and to inform local populations about ways to maintain forests and benefit from the well-being services they deliver. Promotion of good health practices is important, both for rural and poorer populations that may have difficulty in obtaining access to information, and for urban populations that may have adopted poor practices such as unhealthy diets and stressful working conditions.

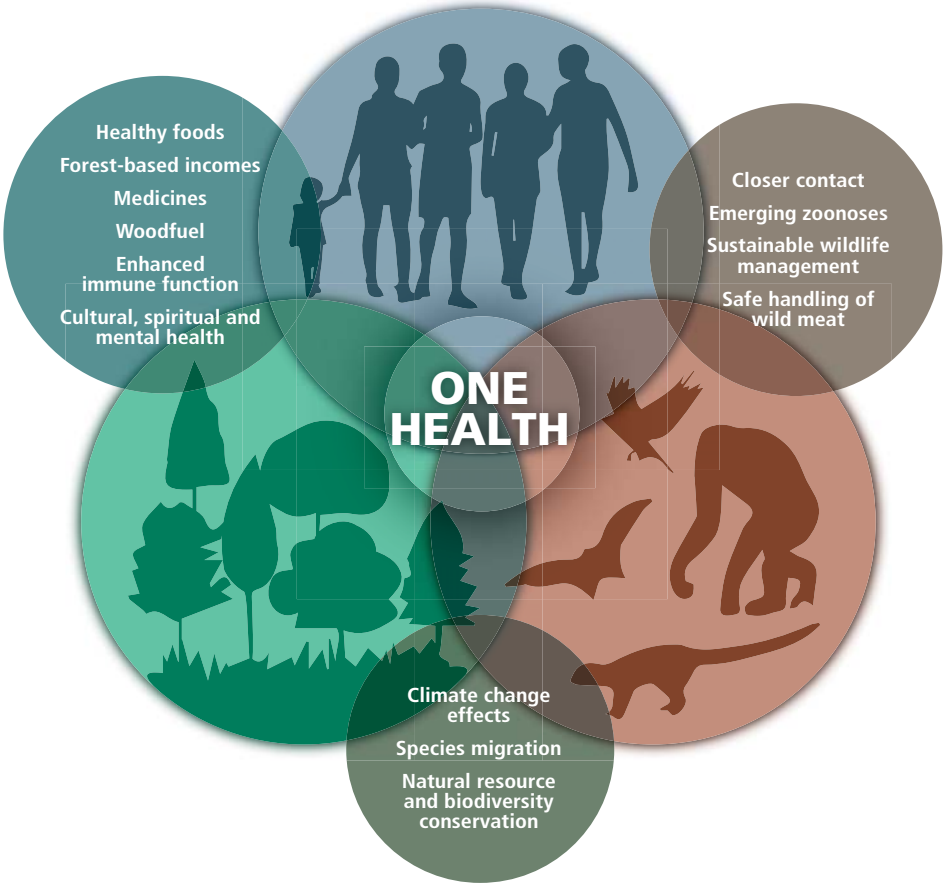
HARMONIZING CONSERVATION WITH LIVELIHOODS AND HUMAN HEALTH

As shown in the preceding chapters, ecosystem integrity underlies human health and development. Opportunities for supporting ecosystem health and human health are wide ranging and must be based

on the principles of sustainability, so that people can benefit from the products and services of forests without depleting the underlying resources. It is essential to address the root causes of environmental destruction, and to harmonize conservation efforts with initiatives to promote livelihood and income generation opportunities for forest communities. Promoting the sale of sustainably harvested forest products, including edible and medicinal products, can enhance the incomes of the poorest people and thus their health, food security and nutrition. Nature-based tourism enterprises may also help diversify rural livelihoods and create jobs.

Especially in developing countries, custodians of sacred sites are natural allies in nature conservation and could facilitate local people's acceptance of necessary conservation measures. In Ethiopia, for example, church forests (small swathes of primary forest conserved around every church) are the community hub of every rural district, and the residing priest is a

FIGURE 9. One Health approach



respected community leader. The church forests have remained protected for many generations, while much of the surrounding landscape has been cleared for agriculture (Lowman and Sinu, 2017).

However, sacred forests are very small patches of forest and cannot be seen alone as a solution. To reverse deforestation and forest degradation trends, it is important that forest communities be enabled to exercise the same rights to manage forests that they exercise over sacred forests, through strong and transparent tenure systems.

In developed countries, protected areas offer outstanding opportunities for urban people to experience the health and spiritual values of nature. An example of a collaborative approach is the Specialist Group on Cultural and Spiritual Values of Protected Areas created by the International Union for Conservation of Nature (IUCN) World Commission on Protected Areas (WCPA). The specialist group investigates the interface between humanity and nature, promotes integrated management of natural and cultural heritage and seeks to harmonize cultural and spiritual aspirations with the conservation of nature. Its Delos Initiative focuses on maintaining both the sanctity and the biodiversity of these sacred sites in developed countries (IUCN WCPA, 2019).

To improve the living environments of urban populations, new reforestation and greening initiatives in urban and peri-urban areas, as well as efforts to sustain existing forest, deserve increased attention in both developed and developing countries.

SUSTAINABLE WILDLIFE MANAGEMENT

A balanced approach to wildlife management is particularly important in light of the role of hunting and trade of wild animals in nutrition and traditional medicine, on the one hand, and in the transmission of zoonotic diseases, on the other. As the rate of urbanization has accelerated, demand from growing cities for wild meat and wildlife products has driven increased hunting, sometimes resulting in unsustainable wildlife offtake. The problem is compounded by loss and fragmentation of wildlife habitat (Fa, Currie and Meeuwig, 2003). Sustainable management practices along the wild meat commodity chain are essential to prevent decline in wildlife species populations, which could have significant impacts on human well-being in rural communities where wild meat use is critical for local livelihoods (Golden *et al*., 2011). Management strategies need to be flexible, integrated and in harmony with different interests, needs and priorities. Strategies should include encouraging sustainable hunting to meet rural demand in a sustainable manner; reducing urban demand for wild meat (providing alternatives); promoting evidence-based, participatory management, with full community engagement and consent; and creating an effective enabling environment through the participatory revision of national hunting laws to ensure that they consider food security, conservation and health concerns, devolution of land tenure to Indigenous peoples and local communities, and establishment of monitoring frameworks (Coad *et al*., 2019).

As a response to the COVID-19 pandemic, China has banned hunting and consumption of all wild meat. However, such a sweeping ban could create food and nutrition security risks for millions of forest dwellers. Any measure to prevent the transmission of zoonotic disease should begin from a local assessment of zoonotic risks linked to wildlife – including a good understanding of wildlife/wild meat value chains and hotspots of disease transmission, the level of dependence of populations on wild meat for food and livelihoods, and drivers of wild meat consumption – as the basis for an informed risk mitigation approach. A ban on hunting and consumption could be a temporary solution where and when zoonotic risks

are high and alternative sources of proteins and other potentially necessary support measures, such as alternative income sources, can be provided. In cities, informal and/or uncontrolled wildlife wet markets and wildlife trafficking should be stopped, and measures should be taken to reduce urban demand for wild meat. In all cases, subsistence hunting should be allowed in areas that lack alternative sources of protein, as long as it is undertaken in a sustainable way (FAO, 2020b; FAO *et al*., forthcoming). It is also crucial to insist on safe, hygienic practices in the handling of wild meat.

VALOURIZATION OF TRADITIONAL KNOWLEDGE

Traditional knowledge about the use of natural forest resources in food security, nutrition and medicine is held by communities and cultures over generations and has deep cultural and economic significance. It is not static, but dynamic, and is usually transmitted orally (FAO, 2018b). Women have a large role in keeping traditional knowledge alive. To valourize their contribution, it is vital to challenge gender bias and stereotypes at all levels (Box 11).

Box 11 Restoring the value of traditional foods

A novel cookbook developed by FAO in Latin America and the Caribbean celebrates women's knowledge and the value of traditional healthy foods from the forest. *Salud, saberes y sabores* (health, knowledge and flavours) (FAO, 2018c) is a compilation of recipes based on indigenous edible plants from 20 countries in the region. Local women present their stories and dishes using ingredients such as wild mushrooms from Mexico, purslane (*Portulaca oleracea*) from Guatemala and the fruit of *Hymenaea courbaril* (West African locust tree) from Brazil. Each story includes information on the nutritional and sometimes medicinal properties of the highlighted ingredient.

Sharing recipes is an innovative way to keep women's valuable knowledge about the traditional use of medicinal and edible plants alive in the face of global change. *Salud, saberes y sabores* gives real meaning to the term "eating well", while promoting the consumption of local family-farmed crops and forest-gathered foods and recognizing the important role of rural and Indigenous women in combating hunger and nutritional problems such as child malnutrition, overweight, obesity and micronutrient deficiencies.

In the face of loss of traditional knowledge of forest medicinal plants and their associated benefits (Reyes-Garcia *et al.,* 2013), a better understanding of holistic nature–human health interactions is needed. Biodiversity needs to be protected not only "for biodiversity's sake" but to enhance those natural systems that benefit the widest number of people, especially the poor (Heywood, 2017). To this end, it is important to raise awareness of the contribution of forest plant conservation and sustainable use to health, food security and biodiversity.

As with all medicines, herbal medicines can have adverse side effects (WHO, 2004). Although they are natural, botanical extracts are used in medicine precisely because they contain pharmacologically active chemicals (Kayne, 2010). Safety continues to be a major issue with the use of herbal remedies, and relevant regulatory authorities have an imperative to protect public health by ensuring that all herbal medicines are safe and of suitable quality (Ekor, 2014). In view of the generally unregulated status of traditional and complementary medicine (T&CM) and inadequate knowledge regarding potential adverse effects of folk remedies, support is needed for more scientific studies and the development of pathways to standardization and integration of traditional medicine in modern medicine. An increasing number of countries already recognize the role of T&CM in their national health systems. In 2018, 88 percent of WHO Member States acknowledged the use of T&CM in formal policies, laws, regulations and programmes (WHO, 2019). However, a number of constraints prohibit them from taking more active steps in integrating traditional medicine into their national health systems, including lack of research data and financial support for research in T&CM; lack of mechanisms for monitoring safety; lack of appropriate mechanisms for controlling and regulating herbal products; insufficient relevant expertise within national health authorities and control agencies; and inadequate channels for sharing information about T&CM among national health authorities.

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Forest people must have the right to share the benefits from the use of their traditional knowledge of forest biodiversity (medicinal herbs traditionally collected from Uzbekistan's forests)

6. WAYS FORWARD

Forests are essential to achieving the Sustainable Development Goals (SDGs), and the 2030 Agenda recognizes the fundamental connection between people and forests. Promoting the linkages between forests and human health (Box 12) can contribute, directly or indirectly, to achieving all SDGs (Figure 10). Sustainable forest management, through which the economic, social and environmental values of all types of forest are maintained and enhanced for the benefit of present and future generations, is the most effective tool for ensuring the delivery of these linkages (UNFF, 2007).

Effective, well implemented and well enforced forest policies and management are necessary to secure the health and nutrition functions of forests and deliver their benefits to citizens. Forest policies, which traditionally focused primarily on the economic contributions of timber

Box 12 **Key facts**

- Good nutrition is an important component of human health. In the same vein, good health is crucial for nutrition, enabling the body to fully use vital nutrients. Therefore, when addressing linkages with forests, it is essential to address health and nutrition at the same time.
- Forests provide a wide range of goods and services that are essential for human health and well-being:
  - forest foods and medicinal plants;
  - forest-derived pharmaceuticals and nutraceuticals;
  - physical and physiological health benefits: general health, improved birth weight, lowered blood pressure and pulse rate, enhanced immune system function, reduced fatigue, control and prevention of non-communicable diseases linked to stress, poor diet, insufficient physical activity and obesity (e.g. cardiovascular and respiratory disease, type 2 diabetes, some cancers);
  - mental health benefits: stress reduction, positive mood, child behavioural development, psychological rehabilitation;
  - improved living environments: protection from air pollution, wind and noise, microclimate improvement, protection of water resources.
- Forests are also associated with some health risks, such as infectious diseases and allergies. Sustainable forest management can have a role in addressing vector-borne and zoonotic diseases (e.g. COVID-19), which are exacerbated by deforestation and forest degradation.

FIGURE 10. Examples of contributions to the Sustainable Development Goals at the forest–human health–nutrition nexus

Forest–health–nutrition nexus supporting livelihoods and well-being required for people to rise out of poverty

All benefits described in this publication

Improved gender equality in forest resources management leading to better nutrition and health outcomes

Woodfuel contributing to good health and nutrition outcomes

Innovative health industries based on forest resources (e.g. forest therapies, pharmaceuticals, nature-based tourism)

Urban forests contributing to a happy and healthy urban populace and community cohesion

Valourization of health and nutrition benefits as an incentive for forest conservation, with resulting climate benefits

Sustainable management and use of forests

Partnerships across sectors (e.g. forests, agriculture, food security, nutrition, health) will enhance the full benefits of forests for nutrition, health and human well-being

Forests contributing to food security and nutrition benefits for all

Good health enabling children to study and learn

Exposure to nature contributing to quality education and children's development

Forests filtering water

Woodfuel for sterilizing water

Good health and nutrition contributing to the ability to work

Forest foods and medicines contributing to economic growth

Access to green space reducing health inequalities

Contribution of forest resources to holistic health care and good nutritional practices, emphasis away from overconsumption of food and natural resources

Mangrove forests sustaining marine biodiversity, a source of nutritious food

Greater human well-being as a whole contributing to peace for all

production, increasingly recognize forests' environmental services as well but are only beginning to address their contributions to human health.

Management for maximizing health benefits requires comprehensive consideration of what health benefits forests provide to users and how the users receive these benefits. However, because the health benefits of forests are intangible, they are not easily measured and therefore not yet adequately recognized. Efforts should be devoted to developing methods for measuring the health benefits of forests, which would also assist in obtaining resource allocation for initiatives linking forests and human health.

Forest management institutions, governmental or community based, should take the lead on delivering health benefits through forests and should include health and nutrition aspects in forest management planning. Such planning must take a cross-sectoral approach, involving schools, park departments, public health departments, public utilities, hospitals, civil society and others. International collaboration is desirable for sharing best practices and relevant data and information.

Information needed to support cross-sectoral decision-making processes for monitoring the forest–nutrition–health nexus includes disaggregated data on topics such as forest cover; health and nutritional status of the population, particularly in forested and urban areas; nutrient composition of local forest foods; collection and consumption of wild forest products used for food, feed and medicine; wildlife monitoring of likely disease vectors; and indigenous medical knowledge with wider application potential.

Despite increasing public awareness of environmental and health issues, many people do not actively engage in behaviours that support human and ecosystem health. Interventions to incentivize behaviour change require an understanding of how specific attitudes towards nature translate into actions and how human behaviours can translate into positive outcomes, based on a vision of humans as part of nature and nature as linked to human well-being (FAO and UNEP, 2020).

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Caju, the fruit of the cashew (*Anarcadium occidentale*), native to northeastern Brazil, is valued for its health-giving properties, including very high levels of vitamin C

To implement forest welfare policies well, legislation governing them is necessary. Issues addressed by such laws include designation of forests for health purposes, plans for managing these forests and delivering health benefits, and regulations governing associated businesses and qualified staff. The Forest Welfare Promotion Act of the Republic of Korea is a good example (Box 13).

In developed countries, forest healing programmes offer opportunities for local economies in terms of revenues and job creation. As seen in the case of Japan, programmes linking the central and local governments and local residents can be an excellent tool for achieving forest environmental benefits and regional development goals. The central government can help with facilities and research for forest healing, local governments and community-based organizations can handle marketing of services and development of techniques and human resources, and local residents can generate revenues by implementing programmes and providing accommodations. Novel marketing concepts, such as "health ecotourism", may assist in harnessing the economic benefits so that jobs and income can be created for

Box 13 **Forest Welfare Promotion Act of the Republic of Korea**

The Forest Welfare Promotion Act (Republic of Korea, 2015) was promulgated to contribute to improving people's health and quality of life and to prescribe conditions for promoting their happiness through the provision of systematic forest-based welfare services, defined as services rendered based on forests, such as forestry culture and recreation, forest education and forest therapy.

The act establishes the obligation of State and local governments to ensure that all people are allowed to benefit from forest welfare services and to establish policies necessary to expand forest welfare services to those who are alienated from them. It calls for establishing a forest welfare promotion plan every five years. To this end, the Korea Forest Service may conduct a basic survey on supply and demand for forest welfare services, forest resource status and relevant land-use conditions.

The act also calls for the establishment of an information system on forest welfare; the provision of forest welfare service vouchers; the registration of forest welfare service providers; and the creation of a forest welfare service certification system. It addresses consideration for mobility disadvantaged persons, support for mountain village residents and preferential employment of local residents.

Rules are outlined for the designation of "forest welfare districts"; these areas exclude, for example, national parks and specified protected areas. Detailed regulations are given for "specialized forest welfare businesses" and "forest welfare complexes" (areas created by establishing multiple forest welfare facilities to provide forest welfare services in a forest welfare district).

This act also resulted in the establishment of the Korea Forest Welfare Institute under the Korea Forest Service in April 2016.

small forest owners and regional residents. Linkages should also be established between health care and social welfare systems. For example, health insurance can be expanded to cover the costs of forest healing programmes, and mechanisms such as a voucher system can be introduced to ensure that economically and socially disadvantaged people are able to receive the health benefits of forests.

As similar age groups generally express common needs, it may be useful to differentiate policies by life stage so as to identify programmes, policies and institutional services that fit the human needs at different stages of the life cycle (Korea Forest Service, 2019).

Replication of such initiatives in developing countries could provide a vehicle to sustainable development while promoting One Health, sustainable forest management, good nutrition and health for all.

KEY RECOMMENDATIONS

- The human health benefits of forests, and people's needs in this regard, will vary depending on the context, particularly between rural and urban areas. The specificity of these contexts should be taken into consideration when planning measures for promoting human health and nutrition benefits as an element of sustainable forest management.
- Countries should adopt a One Health framework emphasizing collaborative policy-making and partnerships across all relevant sectors, such as forestry, agriculture (the primary driver of deforestation), health, nutrition, food security, water, livestock, environment and tourism. The COVID-19 pandemic presents a prime opportunity for emphasizing and taking collaborative actions.
- A network or platform of experts, practitioners and policy-makers is

recommended to facilitate international collaboration, collective discussion of innovative approaches and the sharing of best practices, knowledge, data and information. Such a network can be developed through partnerships among governmental and intergovernmental agencies, the private sector, civil society organizations and research institutions.

- Data pertaining to the forest–nutrition–health nexus should be collected in the context of national forest inventories and other relevant national databases to support situation-specific policy decisions and actions. Harmonization with existing data collection schemes would facilitate assessment of the nexus also at the international level (e.g. through the Global Forest Resources Assessment).
- The forest–nutrition–health nexus provides avenues for innovative policy options not only for the forest sector but also for other relevant sectors outside forestry (e.g. health, tourism). The establishment of novel industries such as holistic forest health tourism can create new sources of income while also promoting physical and mental health.
- Acknowledging the physical and mental health benefits of forests in health care and social welfare policies – for example, allowing health insurance to cover alternative healing practices or the use of forest for health purposes – could facilitate collaboration across the forest and health sectors and improve overall health outcomes, potentially resulting in reduced public health care spending.
- For effective and meaningful implementation of cross-sectoral policies and practices, the support and political commitment of the concerned ministries is vital, as is the allocation of the necessary budget.
- Policy formulation and awareness raising at the forest–nutrition–health nexus must employ gender-sensitive and participatory approaches and involve a wide range of stakeholders, including people who live in and around forests.
- Capacity building at both the community and national levels is necessary to provide the basis for desired changes to maximize and sustain the contribution of forests to human lives and, ultimately, to human health and well-being.

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Forests, font of well-being (United Republic of Tanzania)

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Forests provide, directly or indirectly, important health benefits for all people – not only those whose lives are closely intertwined with forest ecosystems, but also people far from forests, including urban populations. Recognition of the importance of forests for food security and nutrition has significantly increased in recent years, but their role in human health has received less attention. Nutrition and health are intrinsically connected: Good nutrition cannot be achieved without good health and vice versa. Therefore, when addressing linkages with forests, it is essential to address health and nutrition at the same time. Yet forests also provide a wide range of benefits to human health and well-being beyond those generally associated with food security and nutrition. This publication examines the many linkages of forests and human health and offers recommendations for creating an enabling environment in which people can benefit from them. Designed for practitioners and policy-makers in a range of fields – from forestry to food security, from nutrition and health to land-use and urban planning – it is hoped that the paper will stimulate interest in expanding cross-sectoral collaboration to a new set of stakeholders, to unlock the full potential of forests' contributions to greater human well-being.

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